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THE 450-TON HYDRAULIC PRESSES AT SPANISH RIVER PULP MILL.

THE ESPANOLO HYDRAULIC POWER PLANT.

CANADIAN PULP MAKING IN THE ALGOMA DISTRICT ONTARIO.—[SEE PAGE 360.]

COMPULSORY WORKING OF GERMAN PATENTS.

THINGS THE AMERICAN MANUFACTURER OUGHT TO KNOW.

BY GEORGE NEUMANN.

The present German patent law dates from April 7th, 1891, when it took the place of the patent law of May 25th, 1877. It enacts in:

Section 11. After the expiration of three years reckoned from the day of publication following the grant of the patent, according to Section 27, paragraph 1, it shall be revoked:

1. If the patentee neglects to put the invention into practice within the realm to an adequate extent, or at any rate fails to do all that is necessary to assure this practice.

2. If it appears to be required by the public interest that licenses to use the invention be granted to others, but the patentee declines to grant this permission although upon reasonable compensation, and adequate security.

Thus the German Patent Act, in imposing an obligation of working, differs from the original English Statute of Monopolies, of 1623, which is the oldest patent law in the world.

The idea of compulsory working was embodied, however, in the French law of 1762, allowing a year in which to begin the exercise, this period being lengthened, in 1791, to two years of culpable neglect. Other countries followed. After formation of the German Empire, in 1871, there were some doubts as to a patent policy, but these were resolved in 1877 by the framing of a governmental bill for an Imperial patent act. This regulated the working of the inventions as set forth in Section 11 already quoted, applying therein the following principle:

"The revocation of a patent operates first from the moment in which it is canceled; it has, therefore, no reactive (automatic) force."

This provision rests on the theory that it is not expedient to facilitate the death of a single granted patent where the general legal requirements have been complied with at the time of its issue. A fruitful growth of inventions would thus be impeded through the insecurity of the owner of a patent that it was valid. The grounds for annuling a patent are, therefore, restricted as greatly as possible.

This revocation does not take place as the necessary consequence of certain facts designated in the law, but may be put into effect where, in the presence of such facts, the cancelation of the patent is considered necessary by the authorities. The possibility of the revocation is, therefore, a means of warning the patentee that a condition may exist in which it will be necessary.

In the current German legislation, the revocation of a patent is dependent, among other things, upon a patentee's neglect to exercise the patent right, inside the country, within a certain period. The rule has not turned out as was hoped, but has proved generally inadequate.

It is possible to "work" an invention in some simplified manner which does not carry out the spirit of the law to public advantage. The government lacks proper means to make reliable determinations on this question of working. Such a definition as we have affords no guarantee that the use of the invention is not lost to the country. In that respect, therefore, the plan has failed.

Of course, the State cannot leave entirely to the judgment of the patentee whether, and upon what terms, he shall dispose of his patent. There is a danger that he will consider only his personal interests and neglect those of the public. The risk of a misuse is greater, and the evil consequences thereof become the more acute, the longer the duration of the patent under the law and the more competition enters from abroad. A patent ought not so to be employed that the public productive and competitive conditions become unnaturally distorted. Safeguards against misconduct were, therefore, deemed necessary.

Such improper practice can enter in a two-fold manner. First, in this way: that the patentee retains the domestic use of the patent exclusively to himself and denies it to others who need it for their business. If the invention be of such sort that it materially affects labor conditions, the patentee is thereby protected against competition of other manufacturers, sometimes even menacing them with ruin and creating for himself a monopoly. The improper use of the patent may, instead, consist in this: that the patentee does not put the invention into general use within the country, either himself or through another manufacturer, but prefers to reserve the patented industry entirely for foreign use, in order to supply the inland market with products made abroad. In this way also, as the invention reacts upon the manufacturing situation, the life of domestic industries is jeopardized, whereby again the patentee may acquire a virtual monopoly, and even a worse one than in the former case, to the advantage of the foreign country and to the cost of domestic business. Fortunately conditions of trade seldom permit a full carrying out of this assumption. Nevertheless, even if partially and briefly, a force may be at work to distort normal competitive conditions in opposition to public welfare.

The provisions in clauses 1 and 2 are therefore intended to counteract a misuse of the patent protection in the two directions here explained. Clause 1 is intended to prevent a greater or less domestic monopoly by the patentee. Clause 2 is to hinder its use detrimentally to the country in favor of foreign lands. Both provisions are inactive during the first three years (the prospectus of the law named two years) for should the patent be misemployed within such time, no such great harm could accrue to public interests as to necessitate a revocation before the end of the period.

The first provision springs from an assumption that manufacturers will feel a need to use the invention. But if, after the failure of overtures to that end, the offer made to the patentee and by him rejected appears reasonable, the authorities are still not obliged to cancel the patent. Whether he has so put the country to disadvantage as against foreign lands that grounds for such revocation do exist, is difficult legally to determine.

SOME DISTINCTIONS ILLUSTRATED IN ACTUAL CASES.

The German Patent Office and the Imperial Courts, which in the first and second instance are called to consider offers for, and revocations of, patents, have disregarded neither the public good nor the right of the patentee. This is illustrated by the following decisions in actual cases.

A

In order to prevent the revocation, it is sufficient that the subject of invention be brought materially into practice. Immaterial deviations from the patent description are not to be considered.

The Patent Office refused to cancel patent No. 7113, "improvements of rolling mills." It said: "The essence of claim 1 resides in the movable position of a roll which, by means of a lever system, is pressed against a fixed roll in such manner that the former can be separated from the latter so far as is necessary, in order to allow the passage through of hard substances without damage to the rolls. In this element of construction, which is to be considered essential, the roll bench described by Kick and built by Gans & Co., agrees with claim 1. To the number of lever transmissions by means of which the mutually pressed rolls are operated, importance is attached neither in the patent description nor in the phraseology of claim 1. If, therefore, in carrying out claim 1, instead of the complicated lever transmission here provided for, a simple one is brought into use, this circumstance cannot be maintained against the patentee. . . .

"Claim 2 protects . . . a construction, namely, porcelain rolls in roll benches. This construction the defendant has not manufactured at home in the quantity required, and the period of three years has expired. So far as the statutory provisions are concerned, this might lead to a revocation. The Patent Office has, however, found in this case, no occasion for availing of the authority thus granted to it. There has been, first, the controlling consideration that patent No. 7113 presents a unit invention whose . . . component parts, for the purpose of their clearer delineation, are separately expressed in two patent claims. From this point of view, it is . . . sufficient to regard the manufacture as one, in order to excuse the failure to put the other part into practice. Thus we cannot . . . require of a patentee, from considerations of cheapness, especially when he is domiciled abroad, that he manufacture the patented invention in all its parts in this country.

"The law had an eye . . . to the progress of German economic interests. . . . In the present case, however, the crucial point of economic significance for home industries, in the device protected by claim 2, lies not in its manufacture but in its use. It is notorious that the introduction of the W-porcelain rolls into the German milling industry has come to pass extraordinarily; and indeed this advantage is so important that, in comparison with it, the economic benefit which the country might expect from the manufacture of the rolls at home is of relatively little weight."

B

If there be worked only one among several varieties of construction set forth in the patent claim, or only the invention protected in the supplementary patent, and even if all asserted results do not enter, no revocation need be granted.

Cancelation of patent No. 61,345, "automatic fare register," was refused on the following ground: "The Imperial Court entertains no idea that the invention of claim 1, in the form of claims 2 to 4, was worked, and worked to a sufficient extent. . . . This state of affairs affords . . . no occasion to make use of the authority conferred in section 11, clause 1, of the Patent Act to revoke patent claim 1 even partially."

C

The Patent Act makes the authority of the cancelation, section 11, clause 2, dependent upon "public interest." The revocation will be denied even, among other circumstances, when the working of the invention takes place only abroad and not at home and only by a system of rental (within the country).

On May 27th, 1907, was handed down a decision of the Imperial Court that patent No. 105,762, "machine to cover the sewing edges of inner soles with a reinforcement," should not be canceled. "The fact alone that the owner of a mechanical patent merely hires out the machine made according to it will not suffice for cancelation of the patent according to section 11, clause 1, of the Patent Act, when it appears that the hiring system brings economic advantage through the domestic production of goods by the machine. That in itself the plan of using the machine by rental rests upon a sound economic idea, cannot properly be doubted." The court proceeded to cite statistics showing that the renting agreements of this sort in the business of a party here interested were numbered by the thousand. It declared revocation in this case to be out of the question.

D

Under what circumstances the authorities have cause to cancel patents, is indicated by the following decision: Patent No. 55,020, "winding machine" was canceled December 4th, 1907, by decision of the Imperial Court, which said: "The machine in question now sells for a price of not less than 6,000 marks ($1,434) and therefore it cannot be denied that domestic industry has a considerable interest in its manufacture. Such manufacture has not hitherto taken place, but the machine is only imported from abroad, hence the plea of the plaintiff shall be granted, if the defendant cannot maintain special ground upon which the failure to manufacture at home can be justified. . . .

"Section 11 of the Patent Act requires, so far as possible, the manufacture of the invention at home. The patentee is consequently obligated thereto, even at the sacrifice of an advantage; he should not delay until the domestic manufacture becomes remunerative, and must, on his part, make it appear that he has made earnest endeavors. The defendant therefore should not have attached preponderant importance to the fact that a more extensive use has been obtained through the manufacture of his machines in America, but should have presented conditions of license acceptable to domestic manufacturers. That he could have found no licensees, cannot be accepted as proven.

E

Offers to sell or license do not constitute the working of an invention.

In one case the Court explained that, while closing of license contracts affording assurance that an invention would be exploited in the country, sufficed, this was not true of a mere readiness, even if publicly expressed, or of negotiations that miscarried and whose failure was not shown to be due to indifference of the other parties.

In regard to patent No. 23,953, "improvements in machines for reducing soft and yielding substances," the court ignored certain negotiations which had been made after issuance of the complaint in order to furnish proof that the machine could not be made in Germany for the American price. Examining a contract which the defendant had made for the construction and use of certain sizes, etc., in Germany, the court found that he had reserved the more important sizes and was supplying them, to a great value, from America. Revocation was decreed.

Patent No. 104,556, "shoe-sewing machine appliance for varying the distance of the stiches from the edge

of the sole" was canceled, the machines having been made abroad and imported. After issuance of the complaint, their manufacture had begun in Germany, but only for lease to the limited circle using a sewing machine of a certain system. Here also the patent was revoked.

F

The revocation of a patent may be threatened if the holder of an improvement upon the invention be refused the use of the patent under a suitable license agreement, with compensation.

G

A change of ownership taking place during the period of working does not exclude the right of revocation against a later proprietor.

It may be remarked in passing that, in a typical case where this question was involved, the fact that the earlier holder was engaged in American litigation over the invention was held to excuse his failure to work it meanwhile in Germany.

H

Partial revocation is permissible. This is only true, however, where the patent is divisible in its nature.—American Machinist.

LOCOMOTIVE ADHESION.

AN IMPORTANT FACTOR IN DESIGNING ENGINES.

The adhesion of locomotive engines is a most important factor, says The Engineer, in the discharge of their duties. It has to be considered at every step in the preparation of a general design, for on it depends the carrying out of the work done on all the railways in the world, with the exception of a minute proportion of exceptional lines running up the sides of mountains. The word "adhesion" has a special significance attached to it. The late Bridges Adams, who had given it much consideration, always insisted on calling it "sticksion," because, he said, that word better expressed than any other the relation between wheel and rail. When writing about friction its amount is always expressed as a fraction of the weight or force pressing two surfaces together. Thus we may have a coefficient of 1-60th or 0.166 of the insistant weight, this representing the resistance to movement offered by the surfaces in contact. Furthermore, it is to be noted that the fraction is greater for bodies at rest than it is for bodies in motion. That is to say, to start a journal will require a greater effort than will suffice subsequently to keep it going. Locomotive adhesion, however, seems to be different in certain physical characteristics from friction. Its coefficient is enormously larger. It may reach as much as one-fourth, or 25 per cent of the load. It is commonly assumed that on British railways it will amount to one-sixth, or 16.6 per cent. That is to say, let the load on a pair of wheels be eighteen tons; then three tons, acting at a tangent parallel to the rail, will be needed to make them slip, and as adhesion is the limiting measure of tractive effort, then, neglecting the resistance of the engine as a vehicle, it could exert a pull of three tons on the train behind it. All this is in a sense an old story, but the retelling of it will be found useful in clearing the ground.

There is no universally accepted theory of friction. The best is that illustrated by drawing one hair brush over another. The bristles become entangled or interlocked. In the same way the asperities of two metallic surfaces interlace, and in order that movement may take place the roughnesses must be dragged over one another, or dragged off bodily. The old theory of unguents and oils and lubrication generally, was that the oil molecules acted the part of rollers or balls. An asperity was dragged over another, as we might put a stone in a wheeled truck and haul it up a mountain, instead of letting the stone and the mountain come into direct contact. The more recent explanation of lubrication is simple. The oil gets between the surfaces, and they never come into contact at all. Now, in the case of the locomotive driving wheel there can be no uncertainty; beyond any doubt a kind of interlocking takes place. In the days of iron rails scales of metal torn from the rail tables in places where slipping took place were familiar objects glittering in the sun as they lay on the sleepers. We have had in our possession scales five or six inches long, three-fourths of an inch wide, and about as thick as bank-note paper, torn off by a slipping wheel. In this case it will be seen that the slip was almost imperceptible, because the production of a long scale was only consistent with the advance of the wheel on the rail. The gap between the ordinary coefficients of friction for even dry surfaces and that between a wheel and a rail is so great that it is not easy to see that there is much in common between friction and adhesion; and this disparity is due to the very heavy loads forcing the tire and rail together. In our impression for March 25th last, we showed how small is the contact area. There is, we think, no room for doubt that a direct interlocking of surfaces actually takes place, and that it is to this the relatively enormous coefficient of adhesion is due; and yet withal a few spots of oil, or a little "dirt," or a few dead leaves will cut the adhesion down to nothing and render an engine helpless.

A most interesting problem is presented by the question, How can the adhesion of locomotives be increased? If this could be done an immense advantage would be gained; the cost of engines would be reduced; their weight might be diminished; the wear and tear of rails and tires would be lessened. There can be no doubt that the single engine is superior to the coupled engine in every way but one—tractive power. We need do no more than refer to the multiplication of driving wheels as one expedient, but there are others; first, of course, comes the use of sand. No one understands why sand will run up the coefficient of adhesion to two or three times that existing without it. Do the particles imbed themselves in the wheel and the tire and establish a multitude of interlocking points? As first used, dry sand was simply dropped on the rail in front of the wheel and was for the most part wasted. To-day it is blown in in small quantity by a steam blast. It seems remarkable that no one has proposed sending a fine stream of sand and water on the rail. To judge by machines for sawing stone and marble, it is probable that a much smaller quantity of sand would suffice, and it would not be scattered, as it is now, into points and crossings, where, caught by the oil, it gives so much trouble that on some lines the use of sand is specially prohibited in stations and yards, just where it is most wanted. Again, we have pointed out that static friction is much greater than dynamic friction. Now, when a wheel rolls on a rail, that portion of it bearing on the rail is at rest as regards the rail, and the coefficient of adhesion is high. Let the wheel begin to slip and it will instantly spin round; the friction has become dynamic instead of static. It is therefore of the utmost importance to prevent the inception of slipping. But slipping, other things being equal, will depend on the amount of the tangential effort. So long as that remains below a particular figure there will be no slipping. But the tangential effort is not constant; it varies constantly in amount during each revolution, for reasons which we need not stop to explain. The turning moment is much more even with three cylinders than with two, and more uniform with four cylinders than with three, always provided that care is taken to secure that result when designing the engine. The result is that for a given weight a four-cylinder engine will haul heavier trains than will a two-cylinder engine. Moreover, for passenger engines there is another consideration of much importance. At high speeds compensating weights do much harm, tending in each revolution alternately to lift the wheel off the rail and force it down. For this reason we seldom find that more than two-thirds of the reciprocating and centrifugal effort is balanced, and even if it were, it is highly probable that any locomotive running over 90 miles an hour would lift its driving wheels clear of the rails once in each revolution. It needs but a little thought to see that this action must reduce the tractive effort of an engine, and it will be at its worst in the simple engine. But with four cylinders the case is quite different. All the reciprocating and revolving masses balance each other, so that no compensating weights are needed in the wheels. Mechanical purists tell us, indeed, that as compensation does not take place in the same plane, it is imperfect. But the compensation is quite good enough, and so we have another factor tending to promote adhesion.

Lastly, it may be pointed out that were it not for exceptions in the road and conditions of working, the single engine would satisfy every demand that can be made on it, particularly if it was a four-cylinder engine. Most of the heavy pulling done by a locomotive represents acceleration—the work performed in getting up speed. If it were not inconvenient in other respects single engines could be assisted out of station by pusher engines, and would subsequently take care of themselves. The fact is that at high speeds locomotives do not make steam enough to utilize all their adhesion. An engine which can exert a pull of two tons must be exceptionally powerful; and 18 tons on a single pair of drivers would much more than give this. The effect of centrifugal effort mentioned above would not sensibly affect the pull until such time as the train charged an incline, when the resistance would sharply increase. Indeed, it is a common experience that an engine which is running without slipping on a line, or down hill, will begin to slip the moment an incline is reached. This is probably due in part to lifting of the wheels at speed. Four drivers, and even six, are used for fast passenger work solely to deal with comparatively small portions of most railways. At the worst they are never required for more than half their time. Many inventions have been made and patents taken out to augment the coefficient of adhesion. They have come to nothing. There is room to believe, however, that this is largely because no systematic practical study of the problem has ever been undertaken. Slipping is normally due to the rail being "dirty." The coefficient of adhesion on a clean, thoroughly wet rail is very nearly as high as it is on a quite clean dry rail. Much, we believe, might be gained by fitting engines with some device which would clean the rails before them; the surface is very small, a band, say, 2½ inches wide. It would be quite possible to fit a locomotive with two rotary steel wire brushes of considerable diameter, which could be brought into use the moment the wheels began to slip. Again, it is possible that an extension of Stroudley's method of directing exhaust steam on the flanges of the leading wheels might be found to clean the rail. Be this as it may, when we consider how objectionable slipping is, and that it is always due to dirt on the rail, it seems clear that it would be worth while to attempt to clean the rails when they need it in advance of the driving wheels.

In a paper read before the American Chemical Society, Mr. A. P. Steckel described a process for the electro-magnetic separation of non-magnetic, non-conducting substances. The method described is the result of a study of the problem of obtaining a more thorough concentration of Lake Superior native copper ores, and the experiments were carried out at the Buffalo Smelting Works in the years 1905, 1906, 1907. For several reasons the desired result was not fully realized, but the method is interesting, since it may succeed under more favorable conditions. The method is based upon the principle that an electrolyte carrying a current in a magnetic field tends to move across it, whereas non-conducting particles will be unaffected, and conducting particles will move with the liquid. It was assumed in designing the apparatus, that the liquid conductor carrying a given current across a field of given strength would be acted upon by a downward force similar to that which would appear in a solid conductor under the same conditions. As first constructed the apparatus consisted of a trough, 15 inches long, 2 inches wide, and 4 inches deep, placed in the gap of an electromagnet, and filled with water containing a few per cent of sulphuric acid. At the ends of the trough were carbon electrodes, purposely set somewhat inside the bounds of the magnetic field, and carrying direct current to the liquid conductor. Although the performance of this apparatus was in accordance with the theory of the process, it was not found possible, owing to the agitation of the liquid, to attempt the treatment of finely-divided material. Porous woolen screens near the electrodes did not stop this agitation, which was still quite violent, and there was always a marked tendency for the liquid to rise at the ends of the trough and to show a distinct depression in the middle. The liquid was rendered quieter by moving the electrodes from the ends of the trough to a point nearer the middle, leaving only 6 inches of liquid between them, but even under these conditions no satisfactory separation of the finely-divided mixture of copper and rock was possible, although all the large particles of copper went to the bottom and all the large particles of rock remained on the surface of the trough. If a practically quiet condition of the liquid could be maintained in a trough of considerable dimensions the method would be of great value and would fully warrant the expense of installing and operating it. Exhaustive experiments proved, however, that with large electromagnetic forces the liquid could not be held quiet for reasons named in the original article.

A PROFILE PUPPET-SHOW.—II.*

HOW IT CAN BE MADE AND USED.

BY A. ROZE.

Continued from Supplement No. 1795, Page 348.

Attention must now be given to the all-important part of the show, namely, the profile marionettes. Procure some fairly stout cardboard that can easily be manipulated with scissors or penknife. In the case of intricate patterns, a small chisel can be used with advantage. Having the materials and tools, the showman can start making his figures: an easy task if he carefully studies the illustrations to this article, and fully digests the instructions.

Fig. 4 represents a Chinese bellringer, which has five separate movements of the legs, arms, and body, easily understood by referring to the back view (Fig. 5) showing that the limbs of the figure are separate pieces, and that the body is in two parts, six pieces in all. The different pieces are movable, and held in their places by boring a small hole through the two pieces. Then pass a thin piece of copper wire about half an inch in length right through; then bend it flat against the cardboard figure (see left-hand side of Fig. 6). Then, with a pair of round-nosed pliers turn the wire round and flat against the figure, as shown in Fig. 6, right-hand diagram. Then, with the end of wire on the other side, repeat the operation. This method will be the same for jointing all the figures. Having completed the figure, pierce holes with a stout needle, through which the threads have to pass. It

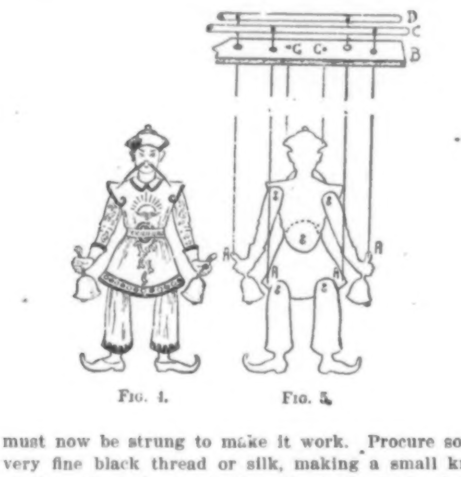


Fig. 4. Fig. 5.

must now be strung to make it work. Procure some very fine black thread or silk, making a small knot at the end, and pass it through at the back of the figure to prevent slipping through and to secure it in its place. A support for the figure is now required, by which it may be worked by the manipulator. This is technically called a crutch. Cut from a flat piece of wood, *B* (a cheap blind-lath bought for a penny will serve), through which drill or bore four holes; next, two smaller holes in the center large enough to pass the threads through, which are then knotted on the upper side of crutch at *C* to hold up the figure. These are called life lines, as they support the figure. Next two narrow pieces of wood or small wooden rods will be required, *C* and *D*. Referring to Fig. 5, it will be seen *A* connected with the arms and lower part of the body; pass right through the crutch *B* the life lines, being fixed as already described. One arm and one side of the body is tied on to *C*, the other arm and reverse side of the body are attached to *D*. The length of the threads depends on the height of the scene over which the entertainer works. They must, in any case, be of such a length that his hands cannot be seen by the spectators.

The figure now being complete, hold the crutch *B* in the fingers of the left hand, and then with the right hand manipulate the rods *C* and *D*. When rod *C* is raised up, one arm of the figure is lifted; also the opposite side of the body, the leg on that side swinging. Then the rod *D* is moved, and both *C* and *D* at the same time. With a little practice, and carefully worked, the effect of a bell-ringing and dancing mandarin will prove an entertaining and mirth-provoking performance. Two or three bellringers will prove more amusing than one. All that is necessary will be to have a longer crutch. The same method will work all the figures. Two or three small sleigh-bells (to be obtained at any toyshop for a few pence) rung at the side by an assistant and in unison with the movements of the figures will give a pleasing effect.

Fig. 7 shows an Eastern lady tambourine-player. Fig. 8 illustrates the crutch method of stringing up the figure, the manipulation being the same as for Fig. 5, and the action of the figure similar except that it will be noticed that the rod *D* will, with a quick movement, give the action of beating the tambourine. The arms in this, as in Fig. 5, are attached behind. Four or five figures, all of which can be

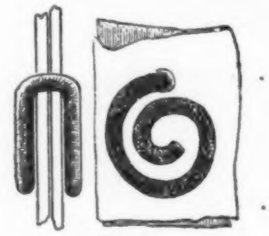


Fig. 6.

worked in unison by making a long crutch (as for the bellringers), will make an attractive and pleasing performance. A quick and dexterous movement to the rod *D* will make it appear as if the figures are beating the tambourines. The threads attached to the hands of the figures must be long enough to allow the elbows to nearly reach the lady's skirt when rod *D* is at rest—of the crutch *B*. A tap with one or more

Fig. 9

sticks on a tambourine at the side of the stage will greatly add to the effect.

Fig. 9 is a grotesque figure of a jockey on donkey-back. This will provide capital fun, especially if several figures are introduced on one crutch, and made to gallop to and fro before the audience, finally galloping off, and should meet with well-deserved applause.

Fig. 10 shows the back view: crutch *B* held in left hand and rod *C* worked by the right hand, as in former figures; but here the animal comes in. Life lines, as already explained for the figures, will be

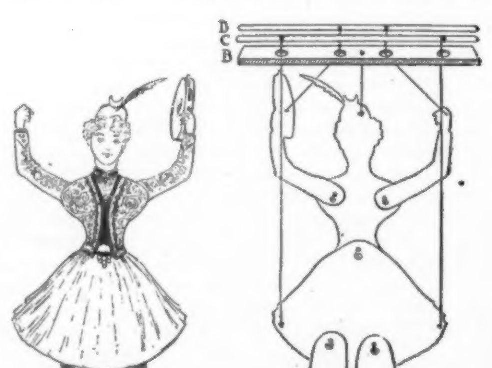


Fig. 7. Fig. 8.

found to vary slightly for Fig. 10, as shown at *A*—one for the head and tail of the donkey, and one for the head of the jockey, *B*, which latter is the all-important one. The donkey is jointed in exactly the same way as the figures. It will be seen that each leg of the donkey is in two pieces; the head and tail are also separate pieces; the body of the animals and jockey in one piece, except the arms, which are fixed in the same manner as other joints, and left to themselves for eccentric movements. A pair of reins made of string and fixed to the hand of the rider, a piece of wire forming the bit for the donkey's mouth. The legs at *E* must have a thread attached which passes freely through the mouth and also at the tail at *F*. The whole being made and fixed, it will be found that by raising or lowering rod *C* the jockey and body of the animal will give a motion that will set the other parts in motion.

(To be continued.)

* English Mechanic and World of Science.

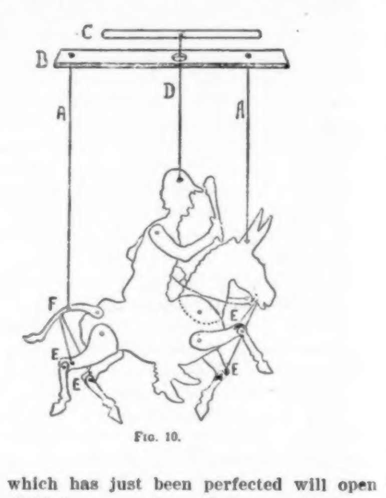


Fig. 10.

NEW CLINICAL THERMOMETER.

Consul-General John L. Griffiths finds that a great deal of interest has been manifested in the British medical world as a result of the invention of a clinical thermometer which, it is stated, automatically registers every fraction of a degree in the changing temperature of the patient. Mr. Griffiths forwards from London the following description of the instrument:

The claim is made that hitherto it has been impossible to record with accuracy the fluctuations in the temperature of the human body, either in sickness or in health. If this is the fact it is evident that the invention which has just been perfected will open a very large field for research work in an entirely new direction. The thermometer consists of a very fine flattened coil of platinum wire, 1-250th of an inch in diameter, wound on a thin strip of celluloid film. This coil is then covered, for the purposes of insulation, by a second thin film of celluloid. The ends of the platinum wire are connected with ordinary copper flexible electric light leads. An extremely sensitive galvanometer, which will instantly record any increase or decrease in the amount of electric current passing, is let into the circuit. The leads then pass to an electric recorder, on which the extent of the variations in the current passing are noted by an upward or downward swing of an ink-tipped pointer traveling on a continuously revolving paper-covered drum or cylinder. The principle underlying the thermometer is that any change in temperature of the coil of platinum wires will vary the amount of current which can pass through it, this change being determined by the galvanometer and recorded on the revolving drum. The thermometer, which is in an insulated celluloid case, is to be placed in the arm pit and kept in position by a bandage which will pass over the opposite shoulder. The arm will also be bandaged to the side in order to protect the thermometer from all atmospheric influences. It is expected that this new instrument will be used chiefly in hospitals in the treatment of such diseases as typhoid fever and pneumonia.—Weekly Consular and Trade Reports.

Statistics of aeronautical patents in recent years are given by Dr. W. A. Dyes in the Zeitschrift für Luftschiffahrt for February. The number of complete patents granted in Germany was 73 in 1909, 36 in 1908, 27 in 1907, 14 in 1906. The corresponding numbers of provisional protections were 140, 48, 37, 14. In view of the fact that in Germany applications for patents are not published until the Patent Office has examined their validity, the author gives for comparison the number of applications filed by the English Patent Office in the same years, namely, 776 in 1909, 224 in 1908, 189 in 1907, 43 in 1906, and 19 in 1905.

COMPASS DEVIATIONS.

THE COMPASS ON BOARD IRON AND STEEL SHIPS.

BY WILLIAM C. WARD.

When the shipbuilders commenced turning out iron and steel vessels navigators found themselves confronted with the problem of overcoming the magnetic forces of their ships and making their compass needles point toward the magnetic north. It became evident that the vessels themselves were tremendous magnets and disturbed the compass in different amounts for each direction in which the ships were headed, the

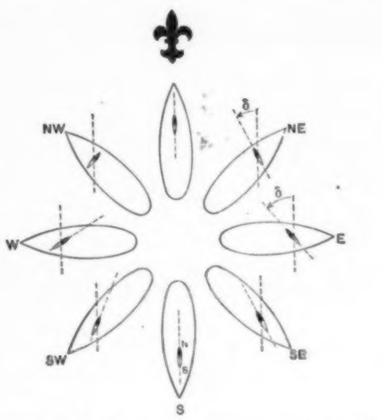


Fig. 1.—Deviations Due to Sub-permanent Magnetism. Vessel Built Heading North-permanent N-polarity in Bow.

quantity of the error being greater or less according to whether the ship's influence acted against or with the earth's total force.

Any elongated mass of iron or steel, whether a bar or a ship, will, when lying in a northerly and southerly direction, acquire by induction from the earth's magnetic field the properties of a magnet. Should the iron be twisted or pounded while in this position it will permanently retain its acquired magnetism. Thus a vessel built heading north will have permanent north polarity induced in its stem with a corresponding south polarity aft; and one built heading northeast will acquire permanent north polarity on the port bow and south polarity on the starboard quarter.

When the vessels are on these headings after launching no deviations of their compasses from magnetic north will be noticed, for the magnetism of the ship and earth will act together in the same straight line. But let one of them be headed east, and it will be found that the north-seeking end of the compass

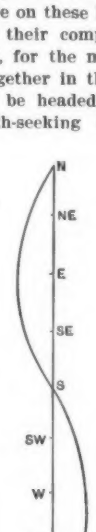


Fig. 2.—Curve of Semicircular Deviations of Vessel Build Heading North.

needle is driven off to the westward by the repelling action of the north polarity in the forward part of the ship—more in the case of the first vessel than the second, because the repelling force is right ahead and more nearly at right angles to the needle's normal position.

If we now head this first vessel southeast the north-seeking end of the compass is still deflected to the westward, though less than before because the angle between the ship's and earth's force is more acute. On the south heading the ship and earth again act in line and there is no deflection. There is an effect, however, because the ship's force strengthens that of the earth, and the needle has a stronger tendency to point north than under normal conditions. For the same reason the compass is rather sluggish when the ship heads north. As the ship swings from south to west the north-seeking end of the needle is deflected to the eastward of magnetic north and the error increases until it reaches its maximum at west, thence decreasing to zero on north. These deviations may be represented as a curve plotted from a base which is a straight line suitably subdivided into the points of the compass. Easterly deviations are plotted to the

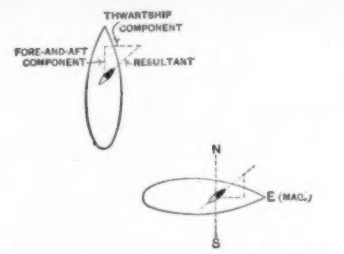


Fig. 3. Horizontal Components of Semicircular Deviations.

right of the base line and westerly deviations to the left, the curve of course crossing the line at the points of no deviation. These points are seen from the figure to be a half circle apart, and it is for this reason that the error caused by the permanent magnetism of the ship is called semi-circular deviation.

The remedy obviously consists of placing a permanent magnet so as to counteract the ship's influence. Formerly this was done literally. The vessel was swung through the entire thirty-two points of the compass and the error carefully determined on each. From

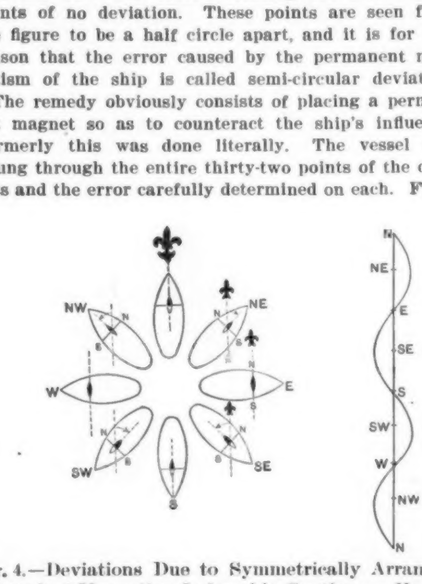


Fig. 4.—Deviations Due to Symmetrically Arranged Transient Magnetism Induced in Continuous Horizontal Iron. The Mean Effect is Shown as an Equivalent Single Beam Through the Compass.

the data thus obtained a long tabulated form of computation was filled out and a result finally evolved which gave the angle between the fore-and-aft line of the ship and the axis of her permanent magnetism. There only remained to place a small steel magnet, wrong end to, with its middle point directly under the pivot of the compass, turn it to the computed angle and raise or lower it until the compass showed proper magnetic readings.

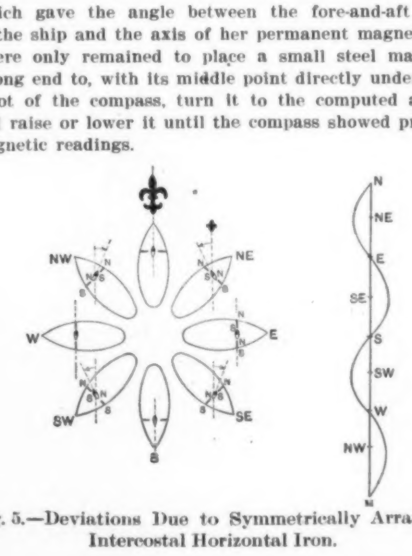


Fig. 5.—Deviations Due to Symmetrically Arranged Intercostal Horizontal Iron.

But the total horizontal permanent magnetic force of the ship may be resolved into two component parts—one fore-and-aft and the other athwartship. Usually we do not know how the vessel headed when building. In such a case when she is heading north the fore-and-aft component is directly in line with the earth's force and cannot cause any lateral deviation. If, then, the compass is found to read northwest when the ship is heading magnetic north, the thwartship component is causing the trouble, and the compass north is being drawn to the eastward by south polarity on the starboard side. We, therefore, place a steel magnet in the thwartship direction with its middle point in the fore-and-aft line of the vessel and its north pole to starboard, moving it toward or away from the compass until the correct reading is obtained on the compass card. Now suppose that the ship is headed east (magnetic) and the compass is found to read northeast. The thwartship component is now acting in line with the earth and can cause no error, even were it not already compensated out. A permanent magnet placed fore-and-aft with its middle point in a thwartship line passing through the compass pivot, north end forward, will drive the compass north off to the left. By now moving this magnet toward or away from the compass until it reads north, the fore-and-aft component will be balanced and the entire semi-circular compensation completed. This latter method being much the simpler is used exclusively to-day.

Whatever permanent magnetism is imparted while building to the thwartship pieces of the vessel, as beams, etc., goes to form part of the semi-circular deviation which has just been explained and com-

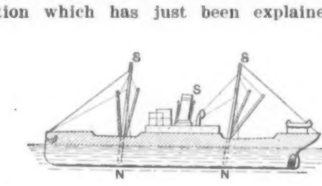


Fig. 6.—Induced Polarity of Vertical Iron.

pensated. But the beams of a vessel being very numerous (generally about two feet apart) and located just below the decks and near the plane of the compass with their extremities comparatively near the midship line in which compasses are located, exercise a powerful influence of varying strength and character as the ship swings through the thirty-two points of the compass and the beams are brought to various angles with the magnetic meridian. As long as the ship heads north or south the beams are at right angles to the direction of the earth's lines of force, and no magnetism can be induced. As long as the ship heads east or west, though the induced magnetism is at its maximum, there can be no lateral effect on the compass needle because ship and earth act in the same straight line. However, as the vessel's head swings from north to east the induced north polarity in the port beam ends repels the north-seeking end of the compass needle off to the right (eastward) reaching its maximum on magnetic northeast, and from there diminishing to zero at east, where the now highly magnetized beams lie north and south. On headings be-

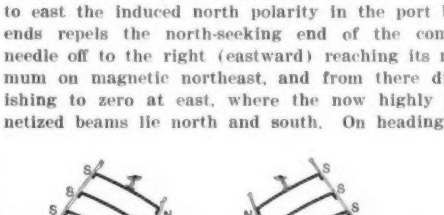


Fig. 7.—Causes of Heeling Error—Transient Magnetism Due to Earth's Vertical Force.

tween east and south the north ends of the beams again act across the line of the earth's force and drive the needle off to the west of magnetic north. Here again the deviation completes its cycle from zero to its maximum (on southeast) and back to zero on south, where the beams lie at right angles to the earth's force and take on no magnetism. In like manner easterly deviations are produced on southwesterly headings and westerly deviations on northwesterly headings. A curve of these deviations, if plotted as before, would cross the line on the cardinal points and exhibit maxima on the intercardinal points, from which circumstance this class of compass error is called quadrantal deviation.

No system of permanent magnets can possibly correct this error which ranges from zero to its maximum and back four times whenever the vessel is turned completely around. It is found, however, that a broken bar of soft iron intercostal with respect to the compass, and which is dependent for its magnetism upon the same conditions as the beam, must, therefore, cause deviations of a quadrantal character; moreover,

such a bar—or two short bars or balls symmetrically placed in a thwartship line through the compass—will cause westerly error whenever the beams are causing easterly, and the reverse. Here the south pole of the port bar attracts the north end of the needle to the westward, where the continuous beam presented a north pole to repel it to the eastward, and so on through the entire circle.

After the semi-circular deviation has been compensated out by the permanent magnets as explained, there only remains to head the vessel northeast (or some other convenient intercardinal point), and move the two iron balls or bars as much as may be necessary to make the compass give the correct magnetic reading.

The reason for heading the vessel north and east (or south and west) to compensate the semi-circular deviation is now evident, for it is on the cardinal points that the quadrantal is always zero. Having once removed the semi-circular error, it is best, though not absolutely necessary, to correct the quadrantal on the intercardinal points where it reaches its maximum.

In rare cases a small error is found which is the same on all headings. This constant may be due to either or both of two causes: unsymmetrical soft iron in the neighborhood of the compass, or the placing of the compass out of the fore-and-aft line of the vessel. In the latter case the remedy suggests itself; in the former no attempt is usually made to compensate, but the error is ascertained and allowed for in laying courses.

A freely suspended magnetic needle, however, will not take up a north-south position in a plane tangent to the earth's surface, but will dip so that it points to the magnetic pole. Its position will be quite vertical at the pole and horizontal only at the magnetic equator. At intermediate points on the earth's surface various degrees of dip will be observed between these limits. Thus the earth's total force is made up of both a vertical and horizontal component. Iron masts, smoke-stacks, boat-davits, stanchions and other up-and-down masses of iron which cannot be affected by the earth's horizontal force, have, nevertheless, magnetism induced in them by the vertical component of the earth's total force, and in north latitudes develop north polarity at their lower extremities. The effect upon the compass needle will depend on which end is nearer at hand; for a compass placed halfway between the extremities would not be affected. The total effect of the vertical soft iron of a ship may be considered as one definite permanent magnetic pole of fixed position relative to the compass and, therefore, must cause semi-circular deviation. In fact the error due to this class of iron is one of the elements that go to make up the total semi-circular error.

As will quite naturally be expected, the strength of this vertically induced magnetism varies with the latitude in which the vessel happens to be. Attempts have been made to correct it by means of vertical soft iron bars (Flinders bar) so placed as to present an opposite vertically induced polarity at the mean or resultant point of application of the vertically induced disturbing force. General practice, however, is to swing ship for deviations and recompensate after any considerable change in latitude.

All that has gone before has referred entirely to ships on an even keel. The moment the vessel commences to roll existing conditions become modified and new forces are brought into play. As the ship heels, say, to port, the port beam ends acquire from the earth's vertical component north polarity (in north latitudes), and the starboard ends the inevitable south polarity. The compass north will then be both repelled and drawn to starboard. On the starboard roll these conditions will be quickly reversed and the compass needle will be forced to port of its proper north direction. Thus, while no fixed error will result, the compass card will vibrate from side to side as the vessel rolls, and the helmsman cannot tell within safe limits what course he is steering. To stop this swinging of the compass card a permanent magnet is suspended—latitude pole uppermost—directly below the pivot of the compass. As long as the vessel is on an even keel there is no effect, but as soon as she heels over, the compass card, tilting in its gimbals, brings this heeling magnet relatively off to one side so that its upper pole counteracts the forces for the time being induced in the upper end of the beams.

THE NEW STANDARDIZED COTTON GRADES.

THE PASSING OF THE EXPERT.

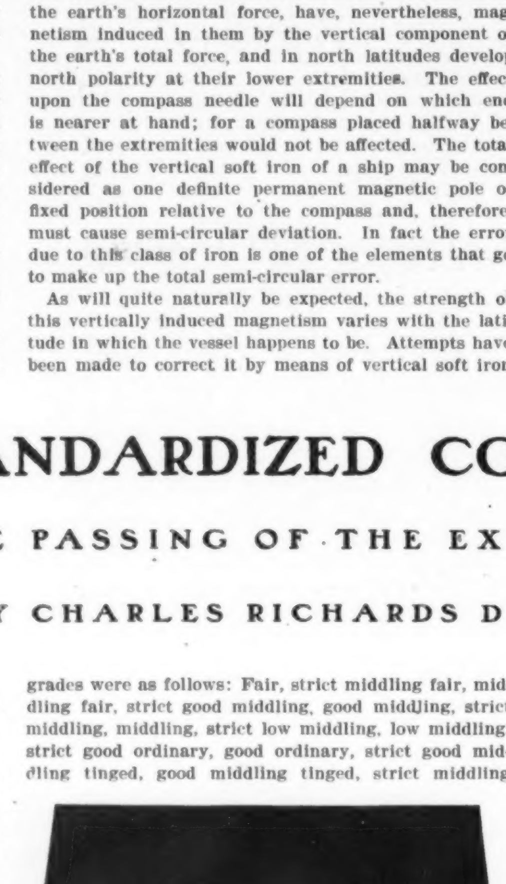
BY CHARLES RICHARDS DODGE.

It has been held that the classification of cotton for trade purposes could never be an exact science, but must depend more or less upon the discretion of experts, and be open to honest differences of opinion. Reduced to a more direct form of statement, it may be said that there have been no uniform standards of grades in the cotton trade, grades of the same name in different exchanges differing considerably in quality, thereby causing wide differences of opinion and much friction in market transactions. Now that a government standardization of grades for a proper and uniform classification of cotton has been effected, when these standards are universally adopted, as they are bound to be, one of the chief causes of controversy in cotton trading—whether relating to "spot" transactions or in the making of contracts for "future delivery"—will have been eliminated.

What the trade itself was unable to accomplish has been effected by officials of the Department of Agriculture without any flare of trumpets, although the action of Congress authorizing the work chanced to be coincident with the *exposé* of the methods of conducting business in the cotton exchanges of the country, which appeared in a special report of the Department of Commerce and Labor. It may be remembered that this investigation of the operations of the cotton exchanges was made by the Bureau of Corporations in accordance with a resolution of the House of Representatives, particularly in regard to the classification methods then in vogue, and to the range of contract grades, these grades being used in connection with the business known as "trading in future." In the report which followed, many suggestions were made whereby the system might be improved, the importance of the early establishment of uniform standards of the leading grades of cotton in all markets being particularly emphasized. Some years ago attempts were made to secure such uniform standards by joint action on the part of leading cotton exchanges, but the movement was without results; and similar efforts made from time to time by the New York Cotton Exchange have failed to meet with response either from the other exchanges or from Liverpool.

The new government standards are the result of a provision which was included by Congress in the appropriation bill for the fiscal year 1908-09, "for the purpose of securing the services of expert cotton classifiers, in order to fix a standard for middling cotton, to be used as a basis to establish standards for nine different grades, these grades to be the official standard of cotton classification." The experts were to be selected by the Department of Agriculture, though it was not proposed to make the standards established by them compulsory by law.

It should be explained that at this time eighteen grades of cotton were recognized by the New York and New Orleans cotton exchanges—ten being full grades and eight being known as "half grades" the latter designated by prefixing the word "strict." These grades were as follows: Fair, strict middling fair, middling fair, strict good middling, good middling, strict middling, middling, strict low middling, low middling, strict good ordinary, good ordinary, strict good middling tinged, good middling tinged, strict middling tinged, middling tinged, strict low middling tinged, low middling tinged, and middling stained. Prior to January 1st, 1908, nine other intermediate grades were recognized, these being known as "quarter grades."



COTTON GRADE BOX SHOWING LABELS.

For legitimate commercial purposes nine grades (as formerly recognized in the older classifications, and as established by the new official standards) are all that are necessary. The classification of cotton is chiefly based on color and the amount of dirt and trash that it contains. The consideration of twice or thrice the nine grades is an absurdity; for while there are experts who are able to detect very minute shades of differences, practically no two experts in differentiating thirty grades, or even eighteen, would be able even to approximate the same results in independent examinations of the same lots of cotton. Hence the "honest differences of opinion" which arise in different exchanges.

The necessity, therefore, for a simple classification is obvious, and it was the aim of the Department officials, acting under the law of Congress, to devise a natural and practical system of grades which, after having been standardized by recognized experts, might be maintained in Washington as types for purposes of future comparison. The Bureau of Plant Industry of the Department of Agriculture having been charged with the work—which was placed under the immediate direction of Dr. Nathan H. Cobb of the Section of Fiber Investigations—with the authority of Congress and with an ample appropriation, the Department began at once the selection of the standardization committee. At the outset the importance of securing as far as possible the most competent and widely known men in the cotton trade was fully recognized; and in time the list of names of the gentlemen who would compose the committee was completed, in its personnel all sections of the country, and all interests in the cotton trade, being represented. Meanwhile standardized samples representing the grades recognized by the cotton exchanges of the country had been secured and held under seal, to be opened by the committee when it should meet in Washington to perform its work.

The committee was as follows: Joseph A. Airey (of John M. Parker & Co.), New Orleans; James Akers (Inman, Akers & Inman), Atlanta; Clifton P. Baker (Lawrence Manufacturing Company), Lowell; F. M. Crump (F. M. Crump & Co.), Memphis; John Martin of Paris, Texas; George W. Neville (Weld & Neville), New York city; L. W. Parker (treasurer Olympia Mills, and others), Greenville, S. C.; Nathaniel N. Thayer (Barry, Thayer & Co.), Boston, and Charles A. Vedder (John D. Rogers & Co.), Galveston—with Mr. Thayer of Boston as chairman. This committee also had the assistance of three expert classifiers, who aided materially in the preliminary work. They were: Jules Mazerat, chairman Classification Committee New Orleans Cotton Exchange; W. P. Barbot, Classification Committee New York Cotton Exchange, and J. R. Taylor, Classer of A. L. Wolff & Co., Dallas, Texas. The foreign members of the committee were not present, as it was not possible for them to attend so early in the year, and it was important that the work of the committee should be finished before the expiration of the Sixtieth Congress.

These busy men unselfishly gave their time, without compensation, for the good of the trade, and at the close of their labors presented a report which while extremely brief covered the whole ground. It was addressed to the Secretary of Agriculture as follows:

"Sir: Having been called upon by you to assist you in the establishment of a standard of middling cotton, and using the same as a basis establishing a standard of nine different grades, to be designated Middling Fair, Strict Good Middling, Good Middling, Strict Middling, Middling, Strict Low Middling, Low Middling, Strict Good Ordinary, and Good Ordinary, in pursuance of the terms of the act of Congress upon the subject, which standards should be the official standards of cotton classifications, beg to advise that in pursuance of the instruction given us, we have made up types representative of each of the grades of cotton referred to above, which we have delivered to your Department, and which we believe to be fair types of the different grades referred to."

It was pointed out by the committee that it would be unfortunate to have the standards used as a basis of sales in the middle of the cotton season, and that they should not go into use by the trade prior to September 1st, 1910. It was urged that the government should at all times maintain the strictest super-

vision of the preparation of the standards, these to be safeguarded in every way by such legislation as might be necessary to prevent their being tampered with.

The date upon which the standards may be used by the trade is approaching. Already they have been adopted, formally, by the New Orleans Exchange, and other southern exchanges are expected soon to follow; New York has not yet been heard from, but it is known that the Exchange has the matter under consideration. As to the foreign exchanges, I can only refer to a recent conversation with Mr. Jules Mazerat, the veteran chairman of the classification committee of the New Orleans Exchange, who stated that members of foreign exchanges visiting in this country are very much interested in the new standards, and with their eyes open are simply waiting. Mr. Mazerat believes that the adoption of the standards by Liverpool and Manchester would mean practically their adoption throughout the world.

The type samples of cotton which make up the nine standard grades are arranged for safe keeping in that number of heavy, cloth-covered cases, measuring about twenty by twenty-one inches, and five inches deep, each case being provided with a tight-fitting hinged lid—a single grade, the cotton samples arranged in twelve compartments, being shown in each case. This is made clear in our illustration, although it should be explained that all which appears in the illustration, above the words "Do not touch the cotton," is merely a bromide enlargement of a photograph of the cotton samples below, which has been affixed to the inside of the cover of the case, picture and samples being afterward photographed together. As the most minute details of the surface of the cotton samples are reproduced in the bromide—such as the positions of particles of dirt or trash, or the "lay" of the cotton fiber itself—it becomes a telltale indicator, any disarrangement, interference, or tampering with the samples being shown at a glance.

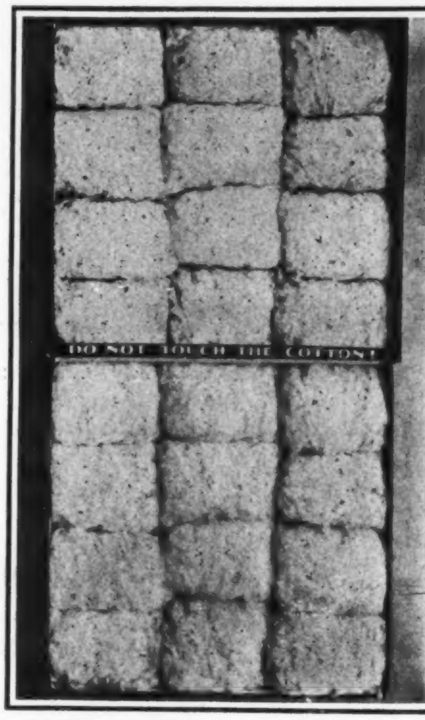
The official label placed on the outside of the cover of the case bears (in blue lettering) the words: Department of Agriculture | Official Cotton Grades; (in gold lettering in an ornamental design) U. S. Standard; (in blue) | American Cotton | of the grade MIDDLING (or other grade as the case may be), with the picture of an eagle in flight, also in blue. Then follows this notice: "The surface of the cotton alone shows the grade. Keep the box right side up. Keep the box closed when not in use, as light and dust destroy the grade. When issued each box bears the seal of the Department of Agriculture and the signature of the Secretary of Agriculture certifying to the grade on the date of issue. The photograph represents the cotton on the date of certification."

On the front end of each case, or box, appears the seal of the Department with the words Official Grade, Middling (or other grade) in blue. The accompanying illustration shows the manner of securing the labels to the case.

The work of grading the cotton samples to standard is carried on by the Department in a special room that has been provided at the top of a building where the light conditions are as nearly perfect as a careful study of the requirements, and the application of scientific principles, can make them. The examination tables are arranged some twenty feet below the skylight, which has a pitch, or inclination, of fifty-three degrees. A pitch of seventy-two degrees, as recommended by the United States Naval Observatory authorities, gives perfect immunity from sunlight at any hour of the day, but this inclination also lessens the volume of light on account of the direction of the light as it enters through the intervening glass. With a pitch of fifty-three degrees better lighting is secured; and in the event of a straggling ray of sunlight entering it can be screened off readily by a narrow adjustable curtain. In finding a location for the grading room, the danger of color reflections from adjacent buildings was duly considered, pure, well diffused, north light, without bars of shadow from the skylight framework or supports being absolutely essential in the work of grading cotton samples to standards.

As lighting conditions must vary in the different laboratories where such grading work is carried on, and as the types preserved at the exchanges are bound to deteriorate in time, and in different degree, the advantage of having always available, in Washington, an official set of true standardized types of grades, for the settlement of disputes, is obvious.

The old problem of regenerating or devulcanizing waste vulcanized rubber is once more made the subject of a patent, granted this time in France to J. C. Bongrand. According to the patent, one part by weight of finely-ground waste is added to 2 to 3 parts of melted paraffin wax (or other oil or fat), and heated at 130 deg. to 150 deg. C. until it is completely dissolved. Lead acetate, or other suitable salt of a heavy metal, is added to the hot mass, and the mixture is thoroughly agitated, in order to precipitate the sulphur as metallic sulphide. The mass is then either (1) extracted with acetone, which removes the paraffin wax as well as oils, resin, etc., and leaves the regenerated rubber still containing all other loading materials; or (2) cooled, dissolved in benzine, petroleum ether, or other solvent of unvulcanized rubber and paraffin wax, the solution freed from mineral matter by decantation or filtration, and the rubber recovered after concentrating the liquid at a low temperature, by precipitation with warm acetone. The rubber is washed with boiling acetone and dried, preferably in vacuo.



OPEN BOX OF GRADED SAMPLES.

USES OF OLD ROPE.

CONSUL-GENERAL ROBERT P. SKINNER, of Hamburg, discusses in a practical way the various uses to which old rope is put at the present time:

My American inquirers apparently are misinformed in understanding that German paper manufacturers have discovered an economical method of removing heavy applications of tar and graphite from old rope. Furthermore, its market price is such that German manufacturers are not interested in making experiments along this line. Heavily tarred old rope is worth more to-day for making oakum than is lightly tarred material, and it does not seem probable that these conditions will undergo any substantial change.

The business of collecting and classifying old rope is an important one in every seaport. Old hemp ropes are nearly all tarred, but there is a small portion of such cordage which has been used for hoisting purposes, or for tying logs into rafts, and this portion is not exported, being converted in Europe into cigarette paper.

More frequently hemp ropes are lightly tarred, the original heavy coating having been washed off by water or melted off by the sun, and can be used for making a cheap grade of oakum, but are used principally in paper making. In Europe the lighter tarred ropes are utilized to a small extent for cigarette paper, but principally for heavy manila, called "papier goudronné." For this the tar remaining in the rope is regarded as desirable. In America few millers use this raw material, and little of it is exported to the United States.

OAKUM PRICES—HEMP WASTE—OLD MANILA.

The best oakum rope is called "wertgau" in German, "cordage pour étoupe" in French, and is worth about 3¼ cents per pound in America. The lighter tarred hemp rope is called in German "getweertes hanftau," and in French "cordage demi goundronné," and this is worth in the United States about 2¼ cents per pound, which explains clearly why it is not worth while to remove the heavy coat of tar for converting the rope into paper.

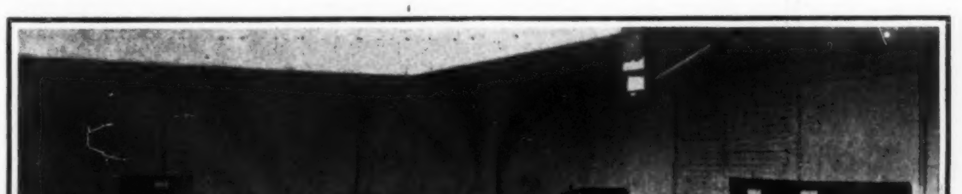
The scraps and waste from these tarred ropes, and also the old oakum removed from the seams of ships are used for making boards and leather boards. This waste was formerly exported to the United States, but latterly American paper makers have found other materials seemingly more suitable for their purposes. The hemp waste is called in English "tarred hemp shakings," in German "lumptau," and in French "cordiles de chanvre goudronné," and it is worth in the United States 1¾ to 1½ cents per pound.

Old manila rope has quite another set of applications. This also comes either white, untarred, or tarred. Of the white, large quantities are collected, the most of which goes to the United States. The shipments to the United States average 2,000 to 3,000 tons per month, American manufacturers using it for producing rope and insulating papers. It is worth 2¼ to 2¾ cents per pound. The American price is held down, so it is said, by a buying combination of consumers. Some years ago the manufacturers had driven the price of this article up to 4½ and 5 cents per pound, whereas, intrinsically, it should not be worth more than 3 cents.

MANILA ROPE PRICES—CHANGING CUSTOMS.

Manila rope, when tarred heavily, is not exported, and is worth ¾ of a cent to 1 cent, and when lightly tarred 1¾ to 2 cents per pound; its exportation to the United States is trifling. European manufacturers absorb most of it for manila and bag papers. Dutch, French, and English ports are the principal sources of supply of tarred manila rope, whereas Hamburg supplies scarcely any of this grade. Some manila rope is not tarred, but tanned, when it is of less value than if tarred.

I am unable to learn that any graphite is used in this country for impregnating rope. I am also informed that American manufacturers, who, ten or twenty years ago, used rope or jute stocks, are now working principally with sulphite pulps, soda pulp, or so-called "kraft" pulps, for the same purposes. By using the newer raw materials, which will produce a fair paper, they get a larger output from their mills, although the quality is not so strong or durable. Rope stock must be cooked much longer than modern pulps. This changed custom has decreased the value of old rope and old bagging considerably, though the demand for paper has increased within twenty years so enormously that ropes and bagging, formerly the sole raw materials, could not now be furnished in sufficient quantities to satisfy the requirements of manufacturers.—Weekly Consular and Trade Reports.



COTTON STANDARDIZATION ROOM.

CANADIAN PULP MAKING.

A PLANT IN THE ALGOMA DISTRICT, ONTARIO.

BY FRANK C. PERKINS.

At the present time there is great interest in the pulp and paper industry in Canada, where there is available an abundance of water power and an abounding supply of raw material. In the Algoma district of the Province of Ontario, with its vast spruce forests and its extensive water power, many desirable conditions are offered to the manufacturer of pulp and paper.

On account of these advantages a great pulp and paper plant has been established at the little town of Espanola on the Spanish River. This stream, some 200 miles in length, has its source in Lake Biscotasing. It follows a winding course to the shores of the Georgian Bay, many important waterfalls interrupting its progress, one of the finest of these, as shown in the accompanying illustrations, being in the neighborhood of Espanola, where the plant of the Spanish River Pulp and Paper Company, Ltd., has been located, and from where the pulp is shipped. The present installation has a capacity of 150 tons air-dry weight per day. This pulp mill is equipped with the latest machinery, as indicated in the engravings, and it contains twenty-four grinders, eighteen wet machines, and twelve 450-ton hydraulic presses.

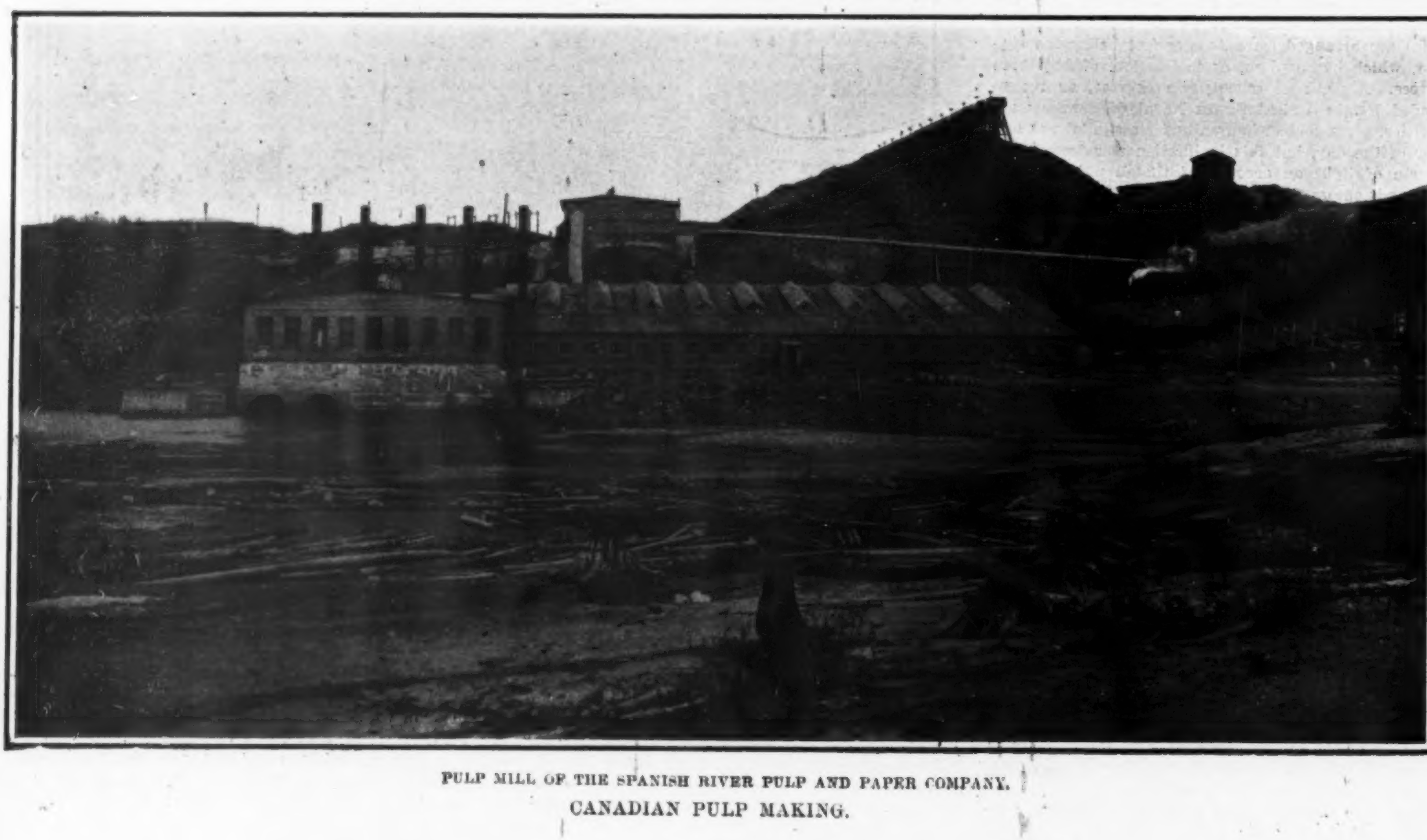
At this Spanish River power plant a head of 62 feet is available, from which 30,000 horse-power can be developed, although only 15,000 horse-power is now being utilized.

A half a decade ago a number of capitalists, on recognizing the immense possibilities that lay in the establishment of a pulp and paper industry in the Algoma district, secured a concession from the Ontario government and at once proceeded to erect a modern plant at Espanola.

It will thus be seen that this great undertaking is of comparatively recent growth. Success, however, was assured from the outset by reason of the sagacity and foresight of its promoters, who secured timber limits comprising an area of about 5,000 square miles in the territory drained by the Spanish River.

A sufficient supply of raw material was thus provided, and recently during a single season 65,000 cords

30,000 CORDS OF PULP WOOD AT THE SPANISH RIVER PULP MILL.



PULP MILL OF THE SPANISH RIVER PULP AND PAPER COMPANY.

CANADIAN PULP MAKING.

of wood were cut. The annual output of the Spanish River pulp mills is said to be 50,000 tons, and it finds a ready market in the United States, particularly in Illinois, Indiana, Wisconsin, and Michigan.

It is interesting to note that in 1905 the Canadian paper making establishments employed about 5,000 men, the wages being over $2,000,000, and the product valued at nearly $10,000,000, the total investment being about $21,000,000.

In the wood-pulp establishments, the material provided had a value of nearly $4,000,000. About $1,000,000 was paid in salaries to 2,456 employees, while the total investment was about $11,000,000. It is maintained that the past five years have shown a wonderful increase in the output of the Canadian pulp and paper mills, and that the growth is the result of the heavy demand for the raw material being met through the utilization of the country's vast and available water power.

IRISH LINEN AND SOME FEATURES OF ITS PRODUCTION.*

By SIR WILLIAM CRAWFORD.

THE first use of linen as an article of clothing is veiled in the mists of antiquity. Linen is mentioned in the Book of Genesis as already in use for robing the royal princes of Egypt, and throughout the Bible it is very frequently referred to in terms of appreciation, and as a symbol of purity and excellence. But it is needless to refer to history in order to prove the ancient use of linen, for considerable quantities of it are actually preserved for us in Egyptian tombs and acknowledged to be of the respectable age of fifty centuries or so. And this Egyptian linen is made of flax which, examined under the microscope, is quite similar in fiber to the flax we use to-day. I may add that some Egyptian linen is marvelously fine, and so thick in proportion to its fineness that nothing similar has been woven in modern times. But the subject I wish to treat of is modern linen of a single locality, and a few special features of its production.

"Irish linen" is of world-wide fame, and perhaps examination of its manufacture may help to explain why it is so. The moist and mild climate of Ireland is admirably suited for the growth of flax and for the successful carrying on of every process of its manufacture up to and including that of bleaching. The flax plant has a thin wiry stem of about three feet, branched only toward the top to carry the pretty blue flower and the bolled fruit which contains the linseed. The fibers run in strands between the skin of the stem and the woody pith forming the center of the stem. When flax is grown for fiber it is never cut, but is pulled up by the roots soon after the fruit is formed. When pulled at it is at once placed, in sheaves, in three or four feet of water, generally in a slanting position, with the top upward. It is there loaded with stones or other heavy material to keep it under water, where retting or fermentation proceeds. The object of retting is to facilitate the separation of the fiber from the skin and woody substance. After ten days or so it is taken from the water, dried, and the fiber is separated. To effect this the flax is bruised and scutched, i. e., beaten by revolving blades of wood. The fiber is then taken to the spinning mill. Various flax-producing countries carry out this process with more or less care. Whether flax is to be spun into yarn by hand or by machinery it has to be hackled, that is to say, combed over sharp-pointed pins till the strips of fibers removed from the stalks of the

* Journal of the Royal Society of Arts.

SPANISH RIVER WATER POWER AT ESPANOLA, ONTARIO, CANADA.

PULP MACHINERY OF THE SPANISH RIVER MILL AT ESPANOLA, ONTARIO, CANADA.

CANADIAN PULP MAKING.

flax plants are divided into apparently single fibers. This division is only apparent, as the ultimate fibers of the flax plant are about 1½ inches long, tapering at each end to an exceedingly fine point. A great number of these ultimate fibers are stuck together by the natural gum in the plant, and form what look like the long fibers resulting from the hackling.

When flax is to be spun by hand, a bundle of this hackled flax is put upon the distaff and a few of these long fibers, differing in number according to the fineness of the yarn to be spun, are, by the selection of the spinner and without any further subdivision, introduced directly into the yarn as it is twisted and wound on to the bobbin in the spinning wheel.

The process of hand spinning, though producing a better thread, is by its nature impossible of application to the spinning of yarn by machinery, as the spinning frame cannot make that selection of individual fibers which takes place in hand spinning. Therefore, in machine spinning quantities of hackled flax, such as are put upon the distaff of the spinning wheel, are fed into a machine called a "spreader," each quantity or piece overlapping the preceding one. These all issue from the machine in one continuous riband or "sliver," which is too thick and too irregular to form yarn. Uniformity is therefore secured by "doubling," and, fineness by "drafting," or drawing out, till it finally appears in the form of rove, a loosely-twisted thread of from five to twenty times the thickness of the yarn required. This rove passes into the hot-water trough of the spinning frame, where the natural gum, holding together the ultimate fibers of the flax, is softened, and upon issuing from the trough the rove passes between two pairs of rollers, the second pair running faster than the first pair, which draw these fibers past each other, thereby extending and reducing the filament to the required degree of fineness, and deliver them to the flyer, which twists them up tight and winds them on to the bobbin. The subsequent drying of the yarn hardens up again the natural gum of the flax plant, and gives the yarn the firmness required to allow of its subsequent handling in the manufacture of cloth or thread.

About eighty years ago a great transformation in flax spinning took place in Ireland. Prior to that time linen yarn was there spun only by hand on the old-fashioned spinning wheel. In the year 1828 Messrs. Mulholland's cotton mill was burned to the ground. They at once, with the enterprise that distinguished the family, decided to rebuild it as a flax-spinning mill. That mill started work in 1830, in Henry Street, Belfast. Part of those same buildings still contain the offices of the York Street Flax Spinning Company, Ltd. About the same time Messrs. Murland, of Castlewellan, also began flax spinning by steam-driven machinery. Messrs. Hind and others in Belfast followed, and by 1850 there were in Ireland 325,000 spindles producing linen yarn. The beginning of the change from hand spinning had already taken place forty years earlier in England, flax-spinning machinery having been invented by John Kendrew and Thomas Porthouse, at Darlington, in 1787. Their spinning frames were rude, and suited only for coarse yarns, but Mr. John Marshall, of Leeds, having taken the invention in hand, improved it, and he also developed the industry and founded a large business. Machine spinning spread also in Scotland, where a mill was erected near Glamis in 1790. But although Ireland was last to begin, not many years elapsed ere it was abreast of England and Scotland. In 1850 Ireland had, as I said, 325,000 spindles, England had 365,000 spindles, and Scotland 303,000. That is to say, there was in 1850 about an equal number of spindles in each, and a little later, in 1856, England attained its maximum with 440,000. Since that time its spindles have decreased, until now the linen trade there seems to be near to the vanishing point with less than 50,000 spindles. Even the Messrs. Marshall have found it necessary to wind up and close their once famous mills in Leeds and transfer their business to the United States of America, where their mills now form part of the Linen Thread Company or Combine. Scotland reached its maximum in 1871, with 317,000 spindles; now it has 160,000; while Ireland's share has increased by a larger number than the other two have lost. Ireland had, in 1875, 906,000 spindles in operation. In 1888 it had 803,000. It has now 935,411 spindles belonging to some fifty different companies—seventeen of them in Belfast, one in Cork, and the others scattered throughout Ulster. One of the reasons of this great displacement in favor of Ireland is because it has practically this one textile industry only, whereas England and Scotland have others which have allowed of a higher profit, and the payment of a higher scale of wages. The number of persons employed in textile factories in Ireland in 1907 was: Flax, 70,382; wool and worsted, 4,103; cotton, 403; silk, 250, and hosiery, 554.

SAWING MACHINES IN OPERATION. CUTTING LOGS FOR USE IN MAKING PAPER PULP.

A CANADIAN PULP MILL.

An average-sized flax spinning mill may contain 20,000 spindles, and a mill of that size would give employment to about 750 persons. It would to-day cost $30 to $40 per spindle to erect it; that means $600,000 to $800,000. The management of such a mill will consist of:

1. The owners of the mill or directors of the company owning it.
2. A mill manager.
3. A head spinning master, a head preparing master, and a head sorting master.
4. A flax buyer and a yarn salesman.

The workers are employed in the proportion of two or three females to one male. A few children of both sexes, and of 12 to 14 years of age, are employed as learners. These are what are called "half timers"; they work and go to school on alternate days, and they cannot be admitted to work unless they attend school.

About $375 are spent in turning $500 of flax into yarn, another $375 in turning that yarn into brown linen, and about $250 in turning that brown linen into white goods ready for market. Thus on $500 worth of flax about $1,000 is spent, chiefly in wages, and the finished product is worth $1,500.

The flax used in Irish mills is the produce chiefly of four countries—Ireland, Belgium, Holland, and Russia.

A new outlet for linen yarns has recently been opened up by the introduction of linen mesh underwear. Ordinary flat woven linen was not porous enough or elastic enough for underwear, but now, by a peculiar system of knitting (or rather by a combination of the two processes of knitting and of weaving) these difficulties have been overcome, and a fabric is produced satisfying all the requirements of hygiene, and eminently suitable for wearing next to the body. Already this new material has met with very considerable success, both in this country and abroad. It is worn and recommended by leading members of the medical profession, and persons who have once experienced the comfort of wearing it are not likely to go back to any other fabric. It is a well-known fact that linen possesses therapeutic properties which are not found in any other fiber; it does not irritate the skin or clog the pores, and at the same time it allows of adequate ventilation. I am confident that this new linen fabric will ere long be largely adopted as a material for underwear.

The flax-spinning business has come through a good many fluctuations of fortune. Sometimes it has been poverbially profitable, and much oftener it has been quite the contrary. For instance, during the American civil war, the shortage thereby caused in the supply of raw cotton turned so many people to the use of linen that the price of linen goods became greatly enhanced, and so during the years 1863-8 spinners made large profits. During that time of prosperity a great increase in the number of spindles took place. But of course when cotton supplies assumed their normal proportions the demand for linen goods diminished, and for the next thirty years or so there were about seven lean years to one fat one. No fewer than thirty-six spinning mills were brought to insolvency, or at least to such serious financial difficulty that eighteen of them, with 200,000 spindles, ceased to exist, the other eighteen continuing under new owners; but even of these eighteen, six have changed owners twice, while one of the largest mills lived through the long-protracted crisis in so crippled a condition that it was unable to pay any dividend to the shareholders during more than twenty consecutive years. On the other hand, a few mills in specially fortunate circumstances maintained a moderate degree of prosperity, and even increased the number of spindles owned by them.

I may now tell you something about the weaving factory. In spinning we had the transformation from hand spinning to mill spinning. In weaving, a similar transformation took place. Ireland began, after England and Scotland, to use the power loom for linen weaving, and in this also it has outstripped them. There are in Ireland 36,000 power looms, owned by 100 companies; 21,000 of these looms are working in Belfast, 13,000 in other parts of Ulster, and 2,000 scattered in small factories in Dublin, Cork, Dundalk, and Drogheda. As compared with the 36,000 power looms in Ireland, Scotland has 17,000, and England 4,400 using linen yarn.

Eight weaving factories in Belfast and eight in other parts of Ireland are attached to spinning mills, but that system is not growing. In 1872, 9,000 looms were attached to mills; now the number is a few hundred less. The growth, or extension, has been in factories separate from mills; in 1872 they were 9,000; now they are 27,000 looms. The chief cause of the growth of factories separate from mills is that a factory must be placed in proximity to a center where workers are to be had who have some dexterity in handling yarn or in weaving; while any saving effected by obtaining yarn from one's own mill is but small.

A power-loom factory for the weaving of light and narrow linens will cost $200 or $250 per loom. A factory for making wide damask or sheetings will cost $500 and up to $1,000 per loom. The management of a weaving factory is composed of (1) the owners of the factory or the directors of the company owning it; (2) a manager; (3) a foreman in the department where the yarns are prepared, with, under (4) a foreman over the warp winding, a foreman over the weft winding, and a warping master; (5) a number of tenters, each one of whom supervises fifty to seventy looms. Generally speaking, one weaver attends to two looms, but for wide goods there is a weaver to each loom. Women attend to the looms weaving narrow and light cloth, and women also sometimes attend to looms making wide and heavy cloth, but many of such looms are attended to by men.

Wages are paid by piecework, and the same scale applies to men and women. The light end of the work is done by women, the heavy end by men, and between the two by either sex. The wages of tenters and other skilled men are comparatively high. The number of all persons employed in and about a weaving factory is somewhere about as many as the looms it contains.

The yarn coming into a weaving factory is in bun-

dles of hanks. For fine linens the yarn is boiled to render it soft and flexible. The warp yarn is taken into the winding department, where from the hank or skein it is put on spools, which are taken to the creel and transferred to a warper's beam. Several of these warper's beams are put on to one weaver's beam, and during this process the yarn is dressed or sized. After the yarn has been put on the weaver's beam the ends of the threads are drawn through the heddles and the reed. These all—beam, yarn, heddles, and reed—are then ready to be placed in the loom so that the weaving may proceed. The weft yarn is wound from the hank to a pirn, which is put into the shuttle, which carries it swiftly back and forward across the loom, leaving the thread inside the shed of the warp.

During the hand-loom period, different classes of linen goods had each its locality of manufacture. The Huguenots, who introduced fine weaving into Ireland, settled at Lisburn and Lurgan. Louis Crommelin, born in 1652, at Armandcourt, in Picardy, and engaged in the linen trade there, was, by the revocation of the Edict of Nantes, forced to fly the country. He was settling in Holland when, on the invitation of William III. he and his son came to Ireland, and by letters patent he was, in 1699, appointed "Overseer of the Royal Linen Manufacture of Ireland." He brought other Huguenots over to assist him. They settled at Lisnagarvey, now called Lisburn, which was then a ruined village; soon, however, they changed the whole aspect of the place into one of prosperity. They taught the farmers improved methods of growing and treating flax, introduced into the country better spinning wheels and looms, and taught how to manufacture cambrics and other fine linens. For the stimulus Crommelin gave to the linen industry he was voted the thanks of the Irish Parliament. He died at Lisburn July 14, 1727, aged 75 years, and is buried with other Huguenots in the eastern corner of the churchyard. One of his discendants, Mr. Nicholas Delacherois Crommelin, was managing partner of the York Street Flax Spinning Company when, fifty years ago, I was serving my apprenticeship there. Since the settlement of the Huguenots the Lisburn neighborhood has continued to be the center of the manufacture of cambrics and lawns, damasks, and bordered linen and cambric handkerchiefs. The word cambric comes, of course, from Cambrai, diaper is cloth d'Ypres, and the word lawn is probably named from the town of Laon. Light shirting linens had their chief center in Ballymena, and a great amount of business was done there. In olden time, and until, say, fifty years ago, the weaver himself brought his web into the market and sold it. By degrees that manner of doing business was superseded by a middleman or so-called manufacturer, who bought yarn in large lots from the spinner, prepared the warps, and gave them out, accompanied with sufficient weft, to the weaver. One of these manufacturers might succeed in having hundreds of weavers thus working for him. It was, then, he who brought the accumulated webs to market. Forty years ago a hundred such manufacturers used to be present at the weekly Saturday market to dispose of the webs of linen which had been woven for them in the surrounding cottages. Thirty years ago the webs offered for sale on a Saturday sometimes numbered 20,000. The York Street Flax Spinning Company have it on record that in 1880, in a time of stagnation, the Ballymena manufacturers had a stock of 40,000 webs. These were worth about $15 per web, of which the weaver's wages had been something like $5 a web. Ballymoney had a reputation for a rather better quality than Ballymena, and Coleraine a little better still. In County Down were woven the heaviest and best shirting linens. Armagh gave its name to the very coarse linens used as buckrams and linings, the trade name of which was "Armaghs." Randalstown produced mosquito nettings and creole checks, which were largely shipped to New Orleans.

But all these hand looms are fast becoming a thing of the past. In every class, the power loom is superseding the hand loom. In 1893 I had occasion to estimat the wages paid annually for hand loom weaving in Ireland, and arrived at a sum of $1,100,000. I estimate the amount so paid now at only $275,000. Parliament, in passing the Handloom Weavers' Protection Act, which came into operation on January 1st, 1910, has made an effort to revive the hand weaving of damasks, cambrics, and diapers, and those engaged in that branch of the industry are laudably striving to take advantage of it. A few years will tell whether or not it will have the desired effect. Another recent Act of Parliament is unintentionally operating to the reduction of hand weaving, as many old people still able to weave a little have abandoned that work on getting their old-age pensions.

(To be concluded.)

THE MOTIONS OF THE EARTH.

THE TWENTY-THREE INFLUENCES TO WHICH THE EARTH IS SUBJECTED.

BY EDGAR LUCIEN LARKIN.

ALONG with the sun and its stately retinue of planets, satellites, asteroids, comets, and meteors, the earth ever moves through infinite space with a velocity of about twelve miles per second, in the general direction of the star Vega. Since this majestic motion was discovered, it has been sought to determine if the sun's pathway is curved or straight: but so far without success. Beyond doubt, however, it is a curve, since it is almost impossible for our own, or any other sun, to traverse a straight line. The motion of bees in a swarm are comparable to those of all suns in space deeps. Another motion is that around the center of gravity of the combined masses of the sun and earth in a period of 31,558,149 seconds, or 365 days, 6 hours, 9 minutes, 9 seconds. This motion is that based on the supposition that no other bodies beside the sun and earth are involved. A third motion is around the center of gravity of the entire solar system. This point constantly shifts slightly, owing to varying positions of all the planets. This motion of the earth is complex. A fourth motion takes place around the center of gravity of the earth and moon, considered to be the only bodies attracting each other. There is a fifth motion around the center of gravity of the sun, moon, and earth, considered by themselves. And this movement is also complex. Motions 6, 7, 8, 9, 10, 11, and 12 are in obedience to the gravitation centers in between the earth, Mercury, Venus, Mars, Jupiter, Saturn, Uranus, and Neptune. These motions are perturbations, and are as difficult to compute as any in astronomy. A thirteenth motion is a slight perturbation due to the feeble attraction of the asteroids; a fourteenth, an increase of the orbital speed of the earth caused by the impact upon it of meteorites, increasing its mass slightly. The fifteenth is a minute perturbation, doubtless due to comets and cosmical dust. In a sixteenth motion we trace a theoretical increase in the velocity of the earth around the sun, due to any resistance it may encounter in ether Precession is the seventeenth motion. The poles of the earth revolve around the poles of its orbit in periods of 25,787 years each. This movement is comparable to the motion of the axis of a gyroscope. This terrestrial motion is caused by the difference of attraction of the sun on the earth as an exact sphere, and upon its equatorial bulge. A diameter of the earth through the equatorial plane is 27.32206 miles greater than through the poles. This protuberance, or massive ring around the earth, corresponds to the heavy rim of a gyroscope. Imagine that the axis of a gyroscope is pencil tipped and prolonged. Set the disk horizontally, spin rapidly, thus the pencil point will describe a circle around a dot on the ceiling of the laboratory room. The huge circles described by the poles of the earth are in diameter twice the obliquity of the ecliptic. Any stars passed by the earth's poles in this majestic motion become polar stars for the time being.

Nutation is the eighteenth motion. The polar pencils would mark out smooth curves if the equatorial ring were acted upon by the sun only. But our exasperating moon, in circulating around the earth once each month, helps the sun pull the ring during half of the month, and opposes it during the other half. This causes the poles to move inside and outside of a true circumference and traverse a wavy path, made up of these semi-monthly undulations. This is called nutation, a word meaning nodding. The moon makes the earth's poles nod. The sun also causes the earth's poles to nod slightly as it passes to the north and south of the equator, which is the eighteenth motion.

The obliquity of the plane of the earth's orbit changes. This is the angle in between the planes of the equator of the earth and its orbit; and is now 25 minutes of arc less than it was 2000 years ago. It will diminish during 15,000 years in the future and then increase. But this causes the earth to move in latitude (its twentieth motion) or north and south of a mean position.

The orbit of the earth is not a circle, but an ellipse, a curve like that of a flattened hoop, with one diameter longer than the other. But the long diameter is now shortening and will so continue during 24,000 years, and then lengthen. This causes a twenty-first motion of the earth toward and away from the sun.

The earth has an axis of figure, but it does not rotate precisely around this, but another nearly coincident. A titanic force is here exerted on the globe, for it wobbles; it does not turn invariably about one permanent axis, but shifts, the displacement being 35 feet approximately. The poles traverse an irregular circle of about 70 feet in diameter, in periods of 425 days each. A mathematical research revealed that if the earth were absolutely rigid, one revolution of the poles would be made in 305 days. The excess of 120 days is due to the fact that it is not absolute in its rigidity: it yields a little, and the amount of yielding is "half that in a globe made of solid steel." The causes of this obscure twenty-second motion or wobbling are unknown, but are thought to be the attractions of the sun and moon. The persistency of plane of rotation of the earth is overcome by this colossal force and turned aside slightly. The power, whatever it is, is able to overcome the momentum of rotation of the huge globe in one plane and establish another. The earth's interior may not be homogenous, and differences of attraction exerted by the sun and moon on places within of unlike specific gravity, may possibly be causes of this remarkable motion of the terrestrial sphere. The discovery of this minute movement was a tribute to the high degree of accuracy of modern measurement. This motion was discovered by means of refined determinations of latitudes made by observing stars. These were found to vary slightly: that is distances of fixed telescopes from the equator of the earth varied, within narrow limits.

Rotation of the earth once in 24 hours is a twenty-third motion.

These twenty-three motions of the earth are of the entire globe as a whole. Perturbations are perplexing, but must be computed when calculations are being made for navigators, for the moon's places, and for eclipses and transits. It is impressive to observe the effects of planetary perturbations on the earth's motions. They are quite apparent in their variations of times of the earth's passage of perihelion. Here is a table giving these disturbances for several years:

Years.	Times of the earth's perihelion passage.
1903	January 3 d. 8 h.
1904	January 2 d. 11 h.
1904	December 31 d. 12 h.
1905	....
1906	January 2 d. 23 h.
1907	January 1 d. 14 h.
1908	January 2 d. 5 h.
1909	January 2 d. 13 h.
1910	January 0 d. 18 h.
1911	January 2 d. 22 h.

Thus in 1905 the earth was not at its perihelion at all; but twice in 1904. Jupiter with its huge mass causes more perturbation than any other planet. There are motions within the earth, and of its surface. Vast areas slowly rise and subside, oscillating in immense periods of time. And tremors are on nearly all the time. Suppose that a siesmograph could be placed in the center of each square mile of the earth's land surface; and that each instrument connected with one central seismograph. Then the latter would be agitated almost incessantly. The earth has no rest. And this is true of its inhabitants. The centrifugal tendency of the earth in its flight reacting against the attraction of the sun is expressed by the words four quintillion tons.

Apropos of our illustration last week of the big California oil gusher, it is interesting to note that the United States Geological Survey estimates that there are deposited in the different fields of California 8,500,000,000 barrels of petroleum; which is more than one-third of the entire amount of oil now stored in the ground of the United States. The next largest are the Appalachian field, with 5,000,000,000, and the Lima, Indiana, field, with 3,000,000,000 barrels. It is estimated that it would take 13,400,000 cars to hold this available oil, and that these cars would make up a train 31,000 miles in length.

MEASURING INSTRUMENTS OF LONG AGO.—II.*

THE MECHANICAL APPLICATION OF GEOMETRICAL PRINCIPLES

BY WILLIAM E. STARK.

Continued from Supplement No. 1795, Page 346.

THE GEOMETRIC SQUARE.

The instrument most commonly referred to in the sixteenth century authors and which appears to have been in use for at least five hundred years is the geometric square (quadratum geometricum). In its simplest form, it consisted of a square frame, two sides of which were marked with scales of equal parts, the number of divisions being usually twelve or some multiple of twelve. These scales, referring apparently to the measurement of altitudes by shadows, were called "umbra recta" and "umbra versa." At the corner of the square opposite the intersection of the scales was pivoted a sighting arm or alidade (Fig. XVIII). In the simplest problem, that of measuring the height of a tower, one edge of the square was held vertically and the alidade was aimed at the top of the tower. The reading where the edge of the alidade cut across the scale was then taken. If the reading was on the "umbra recta," the height of the tower was less than its distance from the observer; if on the "umbra versa," it was greater.

In the first case, assuming the reading to be five and the number of divisions on the scale twelve, the height of the tower was five-twelfths of its distance; in the other, with the same reading, it was twelve-fifths of the distance.

A quadrant was sometimes placed within the square for measuring angular altitudes, and a plumb line was often attached to one edge. Some forms had supporting staffs to which they could be fastened in either a horizontal or vertical position. The early instruments were made of wood and were three or four feet square, but the later ones were of metal. The one belonging to Prof. Smith (Fig. XIX), dating from about 1600, is made of brass and is about twelve inches square. "Umbra versa" and "umbra recta" scales were often engraved on astrolabes. Chaucer, in his treatise on the Astrolabe, 1390, describes this feature, and explains how to solve several problems by means of it.

In another common form of the instrument, for use in measuring altitudes, the square was inscribed in a quadrant (Fig. XXII). Instead of an alidade, the quadrant had sights attached to one of the radial sides and the reading was taken under a plumb line which hung from the center.

An interesting modification of the quadrant form of the geometric square (Fig. XXIII) was devised for the purpose of reducing a distance measured on a slope to a horizontal measurement. Near the center of the quadrant, *BAC*, which is made of wood or metal a graduated straight edge is pivoted. The line *EM*, which represents the position of the straight edge when *AB* is vertical, is graduated in the same way as the straight edge, and a series of semicircles is drawn through the points of division as shown in the diagram. In use (Fig. XXIV) the side *AC* is held parallel to the slope and the straight edge is allowed to take its natural position. Suppose the distance on the slope to be 70 feet. Then the reading of the straight edge where it cuts the semicircle which passes through 70 on scale *EM* gives the horizontal distance. If the slope distance is too long to be applied directly to the scale *EM*, it is divided by two or three for example, and the reading is multiplied by the same number.

A general lack of skill in computation is implied in the proud claims of many authors that with their instruments all calculation is avoided. Belli's square (Fig. XXV) was solid and ruled like a checker board. Holes were bored at the graduation marks along two sides of the square, into which the pivot of the alidade could be thrust. With this device it was possible to make one side of the triangle formed on the instrument correspond in length to the base line, and so to read the required distance directly.

The most interesting problem solved by means of the square was that of finding the length of a line neither end of which is accessible. (Fig. XXVI.) Supposing the required distance to be the height of a tower, two observations were taken from points on the same level and in line with the tower, and the distance between the points of observation measured. The result was then calculated by the following rule: If both readings fall on the *umbra recta*, multiply the distance between the two stations by twelve and divide the product by the difference between the two readings. If both readings fall on the *umbra versa*, divide twelve by each reading in turn and take the difference of the quotients. Divide the distance between stations by this difference. If one reading fell on the *umbra recta* and the other on the *umbra versa*, it was necessary to reduce one reading to its equivalent on the other scale before making the calculation according to the rules. Here is an opportunity for a good algebraic problem. Pupils may verify the correctness of the foregoing rules by stating a pair of simultaneous equations and getting an expression for the height of the tower in terms of the three measurements.

A few of the additional problems mentioned by Finaeus in connection with the geometric square are: (1) To measure a vertical distance from a higher elevation; (2) to measure a distance on a slope; (3) to measure the depth of a well.

THE CROSS-STAFF.

The cross-staff *baculus*, called also the Jacob staff, in its simplest form was a rod of rectangular cross section about four feet long with a short cross-piece having a square hole in the middle. This hole fitted the rod snugly enough to keep the crosspiece at right angles to the rod, but not too tightly to prevent its position being changed.

The staff was marked off into sections equal in length to the crosspiece.

The instrument was used for measuring dimensions of inaccessible objects such as a fort (Fig. XXVII). The crosspiece was first placed at one of the division marks of the staff. The observer then took a position opposite the middle of the line, which he wished to measure, and moved forward or backward until when one end of the staff was placed at the eye, the crosspiece just covered the object. The crosspiece was then moved to the next division of the staff, and the observer took such a position that the object was again exactly covered. The required distance was

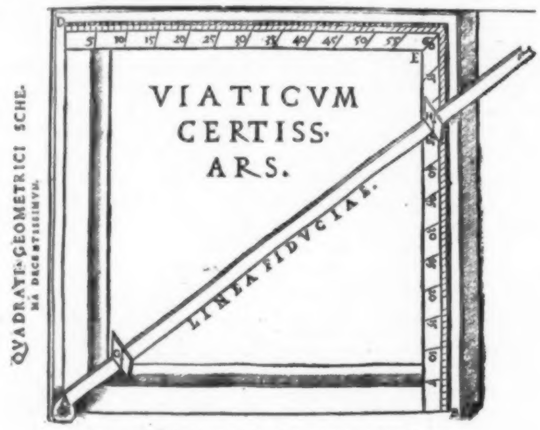


Fig. XVIII.—GEOMETRIC SQUARE.

From Finaeus. See note under Fig. XI.

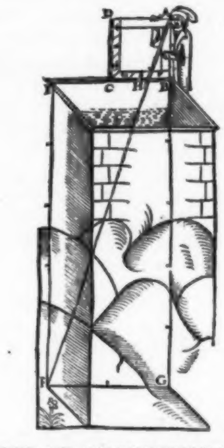


Fig. XXI.—USE OF GEOMETRIC SQUARE IN MEASURING DEPTH OF WELL.

From Finaeus.

Fig. XX.—USE OF GEOMETRIC SQUARE.

From Finaeus.

Fig. XIX.—GEOMETRIC SQUARE OF THE SEVENTEENTH CENTURY.

Belonging to Prof. David Eugene Smith of Teachers' College, New York.

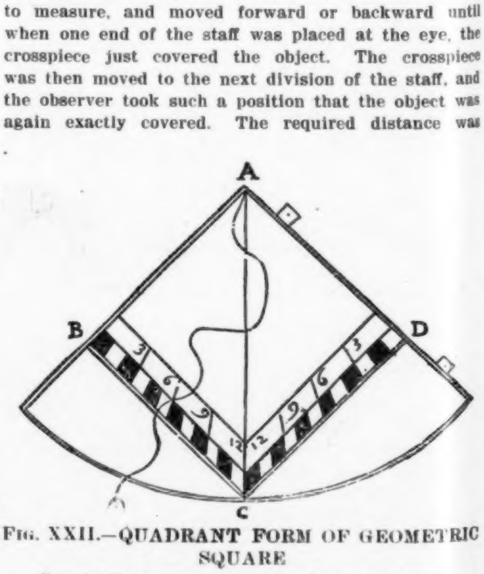


Fig. XXII.—QUADRANT FORM OF GEOMETRIC SQUARE

From Del Modo di Misurare by Cosimo Bartoli, Venice, 1589.

* School Science and Mathematics.

obtained by measuring from one point of observation to the other.

Fiammelli* says that Finaeus and Bartoli, who speak highly of the *baculus*, were mathematical theorists and not practical workmen and that their claims are not justified. He says that it is often impossible to get observations from points as far apart as the length of the required line and gives a general rule for calculating the desired dimension from two observations and the distance between them.

His rule is to multiply the distance between stations by the fractional part of a cross-bar length between the two settings of the cross-bar. To obtain the latter factor with accuracy, he proposes that the principal spaces on the staff be each divided into one hundred parts.

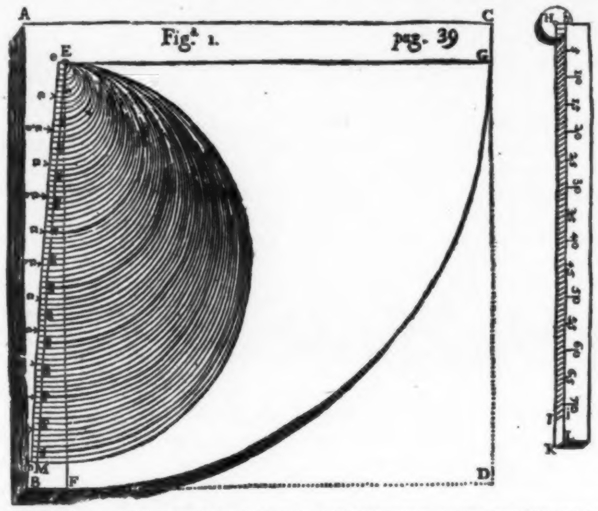


FIG. XXIII.—INSTRUMENT FOR REDUCING MEASUREMENTS ON A SLOPE TO HORIZONTAL DISTANCES.

From Trattato dello Pratica di Geometria by Ludovico Perini. Third Edition, Verona, 1751.

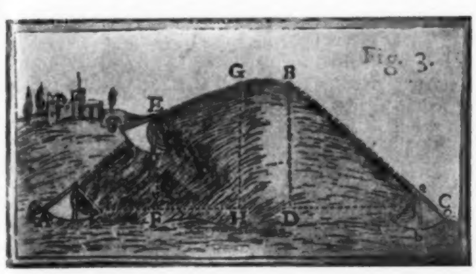


FIG. XXIV.

From Perini. See Fig. XXIII.

The verification of Fiammelli's rule and of the special relation referred to by Finaeus are valuable student's exercises.

SECTOR COMPASSES.

The sector compasses or sector (*compas de proportion*) combined in a single small instrument the means of solving a great variety of problems in arithmetical and geometrical proportion. It was used by architects, surveyors, military engineers, and practical mathematicians generally. It was made in various sizes and some examples were of beautiful workmanship. The earliest description of the sector which I have found is in Bettinus' Apiaria,† 1645, although it is said to have been invented nearly a century earlier.‡

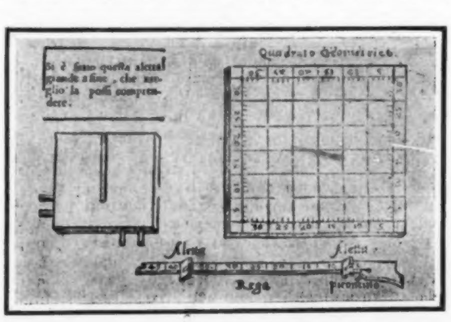


FIG. XXV.—GEOMETRIC SQUARE DESIGNED TO AVOID CALCULATION.

From Belli. See note under Fig. XII.

Though still listed in the catalogues of dealers, this device, which maintained its utility for two hundred years, appears to have been almost completely forgotten.

The instrument consisted of two metal rules, usually about six inches long, joined by a hinge like the common two-foot rule. (Fig. XXVIII.) From the center of the pivot six pairs of lines radiated, three on each face of the instrument. The lines were graduated, the two members of each pair, one on each rule, being in symmetrical positions and marked with identical divisions (Fig. XXIX.)

On one face of the sector of the eighteenth century were the lines of equal parts, the lines of squares, and the lines of polygons. On the other, the lines of chords, the lines of cubes, and the lines of metals. On the first face also there was usually a scale giving the caliber of cannon corresponding to the weight of the ball, and in a corresponding position on the other face a scale of diameters of bullets of given weight. Lines of sines, of tangents, and of secants were added at a later period.

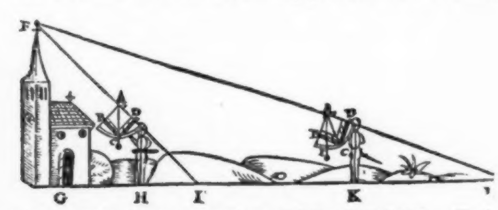


FIG. XXVI.—MEASURING THE HEIGHT OF A TOWER WHOSE BASE IS INACCESSIBLE.

From Finaeus.

In the instrument as described by Bion each line of equal parts was divided into two hundred segments and numbered beginning at the hinge. To divide a line into any number of equal parts, for example seven, take the length of the line on a pair of dividers and, placing one point of the dividers on the point marked 70 or 140 on one line of equal parts, open the compass until the other point of the dividers touches the same number on the other line of equal parts. Then the distance from one 10 (that is from the point marked 10 on one of the lines of equal parts) to the other is one-seventh of the line, from 20 to 20 two-sevenths, and so on.

The foregoing problem will suggest at once the utility of the instrument in drawing to a scale or in measuring distances taken from a map, whose scale is given. The only other problem for the line of equal parts which I shall mention is that of finding a straight line of the same length as the circumference of a given circle. To do this take the given diameter in a pair of dividers and set the compasses so that the dividers span from 50 to 50. The distance from 157 to 157 is then the length of the required line.

The line of squares is simply a scale of square roots, that is, the distance from the pivot to any point on the scale is proportional to the square root of the number standing opposite the point. To find the side of a polygon, whose area is three-fifths of that of a given similar polygon, set the compasses so that the distance from 50 to 50 on the line of squares is equal to the side of the given polygon. Then the distance from 30 to 30 is the required line. Other problems to be solved by the line of squares are (1) to determine the ratio of areas of two given similar polygons, and (2) to construct a polygon similar to two given polygons and equal to their sum or their difference.

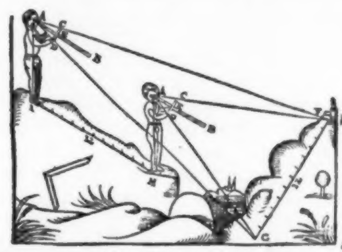


FIG. XXVII.—THE CROSS-STAFF IN USE.

From Finaeus.

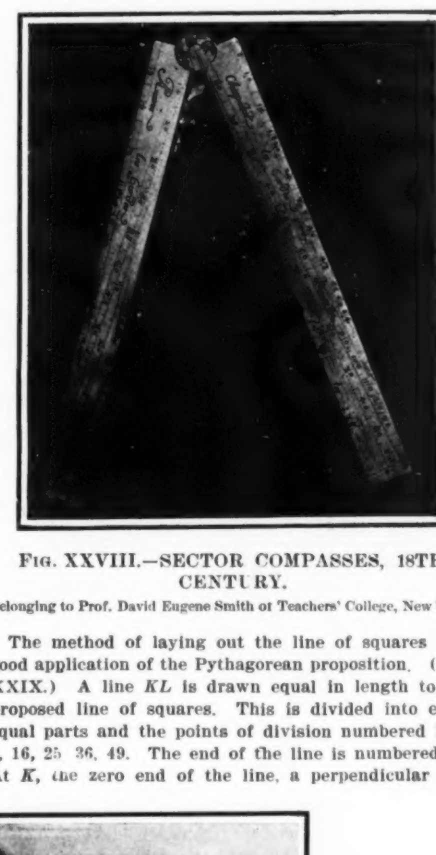


FIG. XXVIII.—SECTOR COMPASSES, 18TH CENTURY.

Belonging to Prof. David Eugene Smith of Teachers' College, New York.

The method of laying out the line of squares is a good application of the Pythagorean proposition. (Fig. XXIX.) A line KL is drawn equal in length to the proposed line of squares. This is divided into eight equal parts and the points of division numbered 1, 4, 9, 16, 25, 36, 49. The end of the line is numbered 64. At K, the zero end of the line, a perpendicular KM is erected equal to one of the eight parts just referred to. Then the distance $M1$ is taken in the dividers and laid off on the line from K. The point found is numbered 2. The distance $B2$ is then laid off from K giving a point which is numbered 3. In general the distance from K to any point is equal to the distance from M to the preceding point.

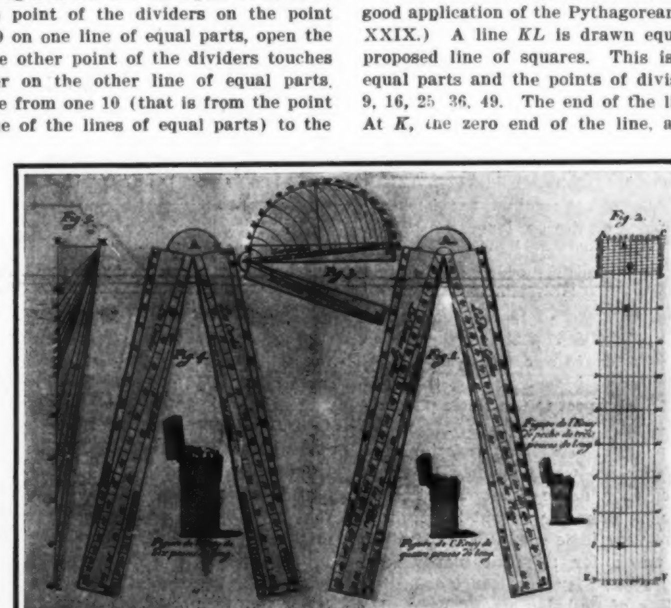


FIG. XXIX.—SECTOR COMPASSES.

From Bion.

* La Riga Matematica di Gio. Francesco Fiammelli, Fiorentino Matematico, Rome.

† Apiaria Universae Philosophiae Mathematicae. Marius Bettinus of Bologna and the Society of Jesus. Bologna, 1645.

‡ International Encyclopedia. Article on Sector.

The line of polygons gives the relative lengths of the sides of regular polygons inscribed in the same circle. As an example of the use of this line, let it be required to inscribe a regular polygon of seven sides in a given circle. Open the sector so that the distance from the points marked 6 on the lines of polygons is equal to the radius of the given circle. Then the distance from 7 to 7 is the length of the required side and may be stepped off on the circumference with the dividers. Other problems for the line of polygons are (1) to describe a given regular polygon on a given side, and (2) to divide a given line in extreme and mean ratio.

On the line of chords (Fig. XXIX, 3) the distance from the pivot to any point is the chord subtending a central angle measured by the number of degrees marked opposite the point, the whole length of the line being the diameter or the chord of 180 deg. To open the compass so that the lines of chords make any desired angle, for example 57 deg., take in the dividers the distance from the pivot to point 57 on the line of chords, and open the compasses until this distance spans from 60 to 60. Other problems are (1) to lay out any desired angle; (2) to measure a given angle; and (3) to take on the circumference of a given circle an arc of any required number of degrees.

The line of cubes is a scale of cube roots corresponding to the scale of square roots on the other face of the compasses. To find the ratio of volume of two similar solids, set the compasses so that the distance from 10 to 10 on the lines of cubes is equal to some dimension of one of the solids. Then take the corresponding dimension of the other solid in the dividers and find the reading on the lines of cubes indicated by this distance, spanned from one line to the other. The ratio of the reading to 10, of course, gives the desired ratio. The line of solids was used to make a scale showing the relation of the weight of a bullet to the caliber of the gun which would fire it; also to divide a gage for measuring the capacity of casks.

The distances from the pivot to the graduation marks on the line of metals are proportional to the dimensions of similar solids of equal weight made of gold, lead, silver, brass, iron and tin. Among the problems solved by use of the line of metals are: (1) to find the diameter of a ball of the same weight as a given ball, but of different metal; (2) to find the relative weight of the various metals; (3) to find the weight of a body of the same size and shape as a given body of another metal.

(To be concluded.)

REMARKABLE COMETS.—II.*

COMETS OTHER THAN HALLEY'S.

Concluded from Supplement No. 1795, page 342.

FEW comets excited greater sensation by their sudden appearance above the horizon than the great comet of 1861 (No. II. of that year). It was discovered by J. Tebbutt, an amateur astronomer, at Windsor, N.S.W., on May 13th, previous to its perihelion passage, which took place on June 11th. Passing from the Southern Hemisphere into the Northern, it became visible in this country on June 29th, though it was not generally seen until the following evening. It is so rare for the inhabitants of the British Islands to have a big comet all their own, as it were, that in this case the multitude of observers and observations was so great that selection is difficult.

A good all-round description was that given by Sir John Herschel, who observed the comet at his house, "Collingwood," Hawkhurst, Kent. He says:

"The comet, which was first noticed here on Saturday night, June 29th, by a resident in the village of Hawkhurst (who informs me that his attention was drawn to it by its being taken by some of his family for the moon rising), became conspicuously visible on the 30th, when I first observed it. It then far exceeded in brightness any comet I have before observed, those of 1811 and the recent splendid one of 1858 not excepted. Its total light certainly far surpassed that of any fixed star or planet, except perhaps Venus at its maximum. The tail extended from its then position, about 8 deg. or 10 deg. above the horizon, to within 10 deg. or 12 deg. of the Pole star, and was therefore about 30 deg. in length. Its greatest breadth, which diminished rapidly in receding from the head, might be about 5 deg. Viewed through a good achromatic, by Peter Dollond, of 2¾ inches aperture and 4-foot focal length, it exhibited a very condensed central light, which might fairly be called a nucleus; but, in its low situation at that time, no other physical peculiarities could be observed. On the 1st instant it was seen early in the evening, but before I could bring a telescope to bear on it clouds intervened, and continued till morning twilight. On the 2nd (Tuesday), being now much better situated for observation, and the night being clear, its appearance at midnight was truly magnificent. The tail, considerably diminished in breadth, had shot out to an extravagant length, extending from the place of the head above o of the Great Bear at least to π and ρ Herculis; that is to say, about 72 deg., and perhaps somewhat further. It exhibited no bifurcation or lateral offsets, and no curvature like that of the comet of 1858, but appeared rather as a narrow prolongation of the northern side of the broader portion near the comet than as a thinning off of the latter along a central axis, thus imparting an unsymmetrical aspect to the whole phenomenon.

"Viewed through a 7-foot Newtonian reflector of 6 inches aperture the nucleus was uncommonly vivid, and was concentrated in a dense pellet of not more than 4 sec. or 5 sec. in diameter (about 315 miles). It was round, and so very little *woolly* that it might *almost* have been taken for a small planet seen through a dense fog; still so far from *sharp* definition as to preclude any idea of its being a solid body. No sparkling or star-light point could, however, be discerned in *its* center with the power used (96), nor any separation by a darker interval between the nucleus and the cometic envelope. The gradation of light, though rapid, was continuous. Neither on this occasion was there any *unequivocal* appearance of that sort of fan or sector of light which has been noticed on so many former ones.

"The appearance of the 3rd was nearly similar, but on the 4th the fan, though feebly, was yet certainly perceived; and on the 5th was very distinctly visible. It consisted, however, not in any vividly radiating jet of light from the nucleus of any well-defined form, but in a crescent-shaped cap formed by a very delicately graduated condensation of the light on the side toward the sun, connected with the nucleus, and what may be termed the *coma* (or spherical haze immediately surrounding it), by an equally delicate gradation of light, very evidently superior in intensity to that on the opposite side. Having no micrometer attached, I could only estimate the distance of the brightest portion of this crescent from the nucleus at about 7 min. or 8 min., corresponding at the distance of the comet, at that time, to about 35,000 miles. On the 4th (Thursday) the tail (preserving all the characters already described on the 2nd) passed through α Draconis and τ Herculis, nearly over π and ϵ Herculis, and was traceable, though with difficulty, almost up to α Ophiuchi, giving a total length of 80 deg. The northern edge of the tail, from α Draconis onward, was perfectly straight—not in the least curved—which, of course, must be understood with reference to a great circle of the heavens.

"Viewed, on the 5th, through a doubly refracting prism well alchromatized, no certain indication of polarization in the light of the nucleus and head of the comet could be perceived. The two images were distinctly separated, and revolved round each other with the rotation of the prism without at least any marked alternating difference of brightness. Calculating on Mr. Hind's data, the angle between the sun and the earth and the comet must then have been 104 deg., giving an angle of incidence equal to 52 deg., and obliquity 38 deg., for a ray supposed to reach the eye *after a single* reflection from the cometic matter. This is not an angle unfavorable to polarization, but the reverse. At 66 deg. of elongation from the sun (which was that of the comet on the occasion in question), the blue light of the sky is very considerably polarized. The constitution of the comet, therefore, is analogous to that of a cloud; the light reflected from which, as is well known, at that (or any other) angle of elongation from the sun, exhibits no signs of polarity."

A very interesting point was raised by Hind, and developed, so to speak, by E. J. Lowe, the well-known meteorologist. Hind stated that he thought it not only possible, but even probable, that in the course of Sunday, June 30th, the earth passed through the tail of the comet at a distance of perhaps two-thirds of its length from the nucleus. The head of the comet was in the Ecliptic at 6 P. M. on June 28th, at a distance from the earth's orbit of about 13,000,000 miles on the inside, its heliocentric longitude (its longitude seen from the center of the sun) being 279 deg. The earth at that moment was rather more than 2 deg. behind that point, but would arrive there soon after 10 P. M. on June 30th. The tail of a comet is seldom an exact prolongation of the radius vector, or imaginary line joining the nucleus with the sun; toward its extremity a tail is almost invariably curved; or, in other words, the matter composing it lags behind what would be its position if it traveled with the same speed as the nucleus. Now judging from the amount of curvature on June 30th, and the direction of the comet's motion, Hind thought that the earth very probably encountered the tail in the early part of that day; or, at any rate, that it was certainly in a region which had been swept over by cometary matter a short time previously. He added that on the evening of June 30th there was a peculiar phosphorescence or illumination of the sky which he attributed at the time to an auroral glare. It was remarked by other persons as something unusual; and it seems scarcely open to doubt that the earth's proximity to the comet had something to do with it. Lowe confirmed Hind's statement of the sky having a peculiar appearance on the evening of June 30th. He says that the sky had a yellow, auroral, glare-like look, and that the sun, though shining, gave but a feeble light. The comet was plainly visible during sunshine at 7:45 P. M. In confirmation of the statement that there was something unusual and indescribable happening, Lowe adds that in his parish church the vicar had the pulpit candles lighted at 7 o'clock, which proves that some sensation of darkness was felt even while the sun was shining. Though unaware at the time that the comet's tail was enveloping the earth, he was so struck by the singularity of what he saw that he made the following entry in his day-book: "A singular yellow phosphorescent glare, very like diffused Aurora Borealis, yet, being daylight, such Aurora could scarcely be noticeable." The comet itself, he states, had a much more hazy appearance than on any subsequent evening.

De La Rue attempted to photograph the comet, but it left no impressions on two collodion plates, although neighboring stars did impress themselves on the plates.

No fewer than eleven envelopes were seen to spring from the head of this comet between July 2nd, when portions of three were in sight, and July 19th; a new one rising at regular intervals every second day. And their evolution and dispersion took place with much greater rapidity than was the case with Donati's comet in 1858; each envelope taking but two or three days to go through its various changes instead of two or three weeks.

On the question of the polarization of the light of the comet, Secchi said:

"The most interesting fact that I observed was this: the polarization of the light of the comet's tail and of the rays near the nucleus was very strong, and one could even distinguish it with the band polariscope; but the nucleus presented no trace of polarization, not even Arago's polariscope with double colored image. On the contrary, on the evenings of July 3rd, and following days, the nucleus presented decided indications, in spite of its extreme smallness, which, on the evening of July 7th, was found to be hardly 1 second.

"I think this a fact of great importance, for it seems that the nucleus on the former days shone by its own light, perhaps by reason of the incandescence to which it had been brought by its close proximity to the sun.

"During the following days the tail has been constantly diminishing, but it is remarkable that it has always passed near to α Herculis, and that it reached to the Milky Way up to July 6th. It would seem that the two tails were nearly independent, and that on July 5th the length and straightness had gone off from the large one, and that this bent itself to the southern side. Last night (July 7th) the long train was hardly perceptible. The light was polarized in the plane of the tail."

Observations on the polarization of the light of the comet were also made by Poey at Passy, near Paris. He found that "the plane of polarization seemed to pass sensibly perpendicular to the axis of the tail." Poey had in 1858 observed Donati's comet for polarization, and found that its light was polarized in a plane passing through the sun, the comet, and the observer.

The comet of 1862 (III.), though not one of first-class magnitude or brilliancy, was nevertheless a very interesting object on account of the fact that a jet of light, frequently altering in form, was observed

* "The Story of the Comets Simply Told for General Readers." By George F. Chambers, F.R.A.S. Oxford: at the Clarendon Press, 1909.

for a long time to emanate from its nucleus. Jets of light shooting forth under such circumstances are not uncommon, as we have already seen, but in the case of this particular comet there seemed an unceasing supply thrown out from the nucleus without any material deterioration of the luminosity of the source of supply. This comet had a tail which on August 27th was 20 deg. long.

The comet of 1874 (iii.), discovered by Coggia at Marseilles, was one of considerable interest. The southerly motion of the comet was so rapid that on July 14th the presence of twilight greatly interfered with the visibility. The following description is from the pen of F. Brodie:

"The head of the comet presented the great peculiarity of having two eccentric envelopes in addition to the ordinary bright envelope immediately surrounding the nucleus. The first envelope was a bright and sharply defined semi-circle surrounding the nucleus; the two eccentric envelopes were nearly as bright, and also very sharply defined, also semi-circular, having their centers placed (about) on the edge of the first envelope, and intersecting each other. The second central envelope just embraced both these eccentric envelopes, and was about half the width of the nebulous head of the comet. Between this second envelope and the ill-defined outline of the head there were faintly marked outlines of other concentric envelopes. The nucleus, which, according to Hind, was 4,000 miles in diameter, appeared to be somewhat flattened on the side opposite to the sun. From this side also the head of the comet divided itself into two distinct parts forming the commencement of the tail: for some distance the bifurcation was remarkably sharply defined, suggesting an intense repulsive force acting upon the nucleus of the comet; and the space inclosed between this bifurcation was strikingly free from nebulous matter. until at some little distance away from the nucleus the sharp definition faded into the general nebulosity of the tail."

The following remarks on this comet are by two French observers, MM. Wolf and Rayet:

"After having maintained for many days a great sameness of form, on June 22nd a series of changes in the shape of the head of the comet commenced. On that day the comet, viewed with a Foucault telescope of 40 centimeters (15¾ inches), appeared to be inclosed in the interior of a very elongated parabola. Starting from the nucleus, which was placed, as it were, at the focus of the curve, the brightness decreased gradually toward the summit: but the interior of the parabola the diminution of the brightness was sudden, and the boundary line exhibited another parabola a little more open than the first, and having at its own summit the brilliant nucleus itself. The outline of the parabola which passed through the nucleus was prolonged so as to form the lateral boundaries of the tail, the edges of which were well defined and were much brighter than the interior parts. This tail had then the appearance of a luminous envelope hollow in the inside. The nucleus was always very sharp. On July 1st the general form of the comet remained the same; it appeared always to possess a parabolic outline at its exterior edge. The nucleus, however, jutted out into the interior of the second parabola, and the opposite margins of the tail were not strictly symmetrical. The west side, that is to say the side which had the greatest R.A., was very sensibly brighter than the other. . . . From July 5th, the want of symmetry spoken of above became more and more marked, and near the head the decrease of the brightness became less regular. On July 7th, the contrast between the two branches was striking, the western branch of the tail being about twice as bright as the eastern. At the same time the nucleus appeared to be becoming diffused, and it seemed to fade away in the direction of the head of the comet, although still sharply defined on the side nearest the tail; one could not fail to remark its resemblance to an open fan. . . . Our last observation of the comet was made on July 14th at 9:30 P. M.: important changes in the aspect of the head had manifested themselves. The fan of light had disappeared on the west side, and was replaced by a long spur of light which was traceable for a considerable distance across the head; on the west side the remnant of the fan terminated abruptly, and the boundary line there made but a small angle with the main axis of the comet. On this same occasion two rays of light were visible—two jets as they might be deemed—thrown forward, the one to the right and the other to the left; these luminous rays seemed to have their origin at the edge of the fan of which they formed a sort of prolongation. The ray which pointed toward the east projected well forward, and being bent round toward the tail soon reached the preceding edge of the comet; it was faint and hardly surpassed the nebulosity in brilliancy. The ray projected toward the west was much more brilliant, and was similarly bent round toward the tail, which it assisted in providing with a bright exterior edge."

The comet was nearest to the earth on July 21st, when its distance was less than it had been on July 13th by 9,000,000 miles. During this week the comet's tail remained visible, stretching toward the north for some hours after the nucleus had descended below the horizon. It would have been an exceedingly striking object all this week if it could have been seen as a whole, but it had got too close to the sun. The tail reached a length of 43 deg. on July 19th, but on the evening when Brodie's sketch was made it was no more than 20 deg. Coggia's comet undoubtedly revolves in an elliptic orbit, but there is great discordance in the values given of the period. Seyboth's period is 5,711 years; but Geelmuyden put it as high as 10,445 years.

The comet of 1880 (i.), generally called the "Great Southern Comet of 1880," was noticed by several persons in Australia, South America, and South Africa on February 1st, but its cometary nature seems not to have been recognized till the following night. Gould at Cordoba described the tail as 40 deg. long and from 1½ deg. to 2½ deg. broad, but at no time was the nucleus very bright. The elements closely resemble those of the great comet of 1843, also celebrated, as we have seen, for the length of its tail, but the identity of the two bodies has not yet been satisfactorily established. This comet was unfavorably placed for observation, and was only seen for two or three weeks.

The comet of 1882 (iii.) was in some respects one of the most remarkable seen by the present generation of astronomers. It was conspicuously visible to the naked eye for some weeks in September, and altogether remained in sight for the long period of nine months. The special peculiarities which seem to differentiate this comet from all others which have been exhaustively scrutinized, either before or since, were that the head underwent changes in the nature of disruptions; that the tail may have been tubular; that the extremity of the tail was not only bi-fid (or split), but that it was entirely unsymmetrical, considered in relation to the greater part of the tail; and that on one occasion the comet seems to have thrown off a mass of matter which became, and for several days was observed as, a distinct comet. The changes which took place in the nucleus and head were noted and described by many observers. Prince wrote:

"October 13th.—I could notice, however, that there was a decided change in the appearance of the nucleus. Instead of being of an oval shape, it had become a long flickering column of light in the direction of the tail."

"October 20th.—I noticed, however, at once, that a still further change had occurred in the nucleus since the 13th, which amounted, in fact, to its disruption into at least three portions."

"October 23.—The disruption of the nucleus which I had noticed on the 20th was now fully apparent. The nucleus proper had become quite linear, having upon it the four distinct point of condensation. The linear nucleus, with these points of condensation upon it, was surrounded by a distinct oblong coma, which was rounded off at the lower extremity, while the upper portion, following the direction of the tail, terminated more decidedly in a point. Mr. G. J. Symons, F.R.S., was with me in the observatory, and his impression was that there were *five* points of condensation, and he remarked that 'the nucleus was like a string of beads.' At intervals I thought there *was* another point of light, but I could not absolutely satisfy myself of its objective existence. Both Mr. Symons and myself particularly noticed the frequent flickering of the light of the nucleus, which was quite apparent both to the naked eye and in the telescope."

J. F. J. Schmidt published a sketch of the nucleus which is not unlike Prince's; and having seen Prince's he refers to it as a good representation of what he had seen himself. He noticed a vibratory motion of the fan.

The suggestion that the comet's tail was tubular in form is due to Tempel, who brought out the idea in some striking sketches which he sent to the Royal Astronomical Society, accompanied, for the sake of comparison, by a drawing of the appearance of two hollow glass cylinders as seen in the focus of an eyepiece.

The peculiar shape of the tip of this comet's tail was mentioned by most observers. This feature, though rare as regards the comets of the last half century, may be conceived to be the shape meant by old writers when they speak (as they often do) of having seen a comet resembling in form "a Turkish scymitar."

The most noteworthy physical peculiarity of the comet of 1882 was its throwing off a mass of matter which became a satellite comet, as recorded by Schmidt at Athens, and by Barnard and Brooks in America. Perhaps it is going too far to speak quite as definitely as this, but the fact is clear that Schmidt saw on October 9th, and on two or three later days, a nebulous mass in the neighborhood of the comet which calculation indicated to be cometary matter moving round the sun in an orbit considerably resembling the orbit of the comet. Brooks's observation made on October 21st was that he saw a nebulous mass on the opposite side of the comet to Schmidt's mass. With the evidence before us of what happened in 1846 in the case of Biela's comet, it is impossible not to draw the inference that the nebulous mass (or masses) was, or had been, a part of the comet itself; and this theory becomes much strengthened when read in the light of the disruptive changes which the nucleus underwent as already mentioned.

Gen. Willis observed the comet at sea 70 miles east of Gibraltar on October 19th at 5 A. M. with the air extremely clear and calm. He says that in appearance the comet was so "extremely delicate, light, and airy, that it would be almost impossible to depict it on paper."

Holden contributed some information bearing on the question of disruption. With reference to the compound nucleus of the comet on October 13th and October 17th, it may be remarked that two of the nuclei seen by Holden were seen by Cruls at Rio de Janeiro at the intermediate date of October 15th. Cruls found these nuclei to resemble stars of the seventh and eighth magnitudes respectively, the distance between them being 6¾ sec. He was led to regard the peculiar appearance of the tail as being really due to two tails, one superposed upon the other, each connnected with a nucleus of its own, independent of the other.

Not only did this comet puzzle astronomers very much in the matter of its physical appearance, but its orbit has also been a source of great searchings of heart. The elements closely resemble those of the comet of 1880 (i.). This in turn was considered to be a comet moving in an elliptic orbit with a period of about 37 years, and to be in fact a return of the celebrated comet of 1843. It still remains a moot point what interpreation is to be cut upon these orbital resemblances, the fact of which cannot be questioned. And there is the further complication that since the advent of the comet of 1882 another one has presented itself, namely, the comet of 1887 (i.), whose elements also bear a strong resemblance to those of three comets just mentioned. The suggestion has been made that these four comets, all of them large ones (and perhaps another also), had a common origin, but that by some process of disintegration the original mass yielded four or more fragments which, pursuing paths only slightly different, have arrived at perihelion at different epochs. It will be seen at once that this is a very speculative question.

The comet of 1887 was seen only in the Southern Hemisphere. It seems to have been first seen in South Africa by a "farmer and fisherman" at Blauwberg near Cape Town on January 18th. Finlay, who first saw it on January 22nd, describes it as "a pale, narrow ribbon of light, quite straight, and of nearly uniform brightness throughout its length. There was no head or condensation of any kind visible near the end, the light simply fading away to nothing." The tail was described by Todd, at Adelaide, Australia, as a "narrow nebulous streak"; but the remarkable thing is that the tail was as much as 30 deg. or more long, according to several observers. To both Finlay and Todd this comet recalled the great Southern comet of 1880 as regards its appearance, and Finlay was so impressed by the resemblance that he took steps to investigate its orbit, and, strange to say, found that the resemblance even extended to that detail. His conclusion was thus expressed: "These elements, though of course rough, prove conclusively that the comet belongs to the family of 'Sun-grazers' of which 1843 (i.), 1880 (i.), and 1881 (ii.) are members."

Sawerthal's comet of 1888 (i.) exhibited on March 27th a triple nucleus not unlike that of the great comet of 1882. This comet had a tail which on April 11th was 5 deg. long. It revolves in an elliptic orbit to which a period of 1,615 years has been assigned. The configuration of the head was very remarkable and unusual.

The comet of 1901 (i.), discovered at Paysandu in South America on April 12th, but scarcely reached from any observatory in the Northern Hemisphere except the Lick, in California, has some claim to be called "remarkable." Its main tail, which did not exceed 10 deg. in length, was preceded by a faint tail fully 30 deg. long, which branched out from the main tail, making with it an angle of about 40 deg. or nearly half a right angle. On April 24th, although in twilight, the nucleus was very bright and distinctly of a yellow tinge, as seen by Innes at the Cape Observatory. On May 12th, though the comet had become intrinsically much fainter, it was still a magnificent object, and in between the two tails spoken of above two other slender tails were visible. The spectrum appeared to be continuous. The comet was visible for about six weeks, but bad weather both at the Cape and in Australia and the comet's inconvenient position with respect to the sun interfered very much to prevent a good series of observations. On May 2nd the nucleus is said to have rivaled Sirius in luster and to have been distinctly elliptical in shape. Eddie, at Naauwpoort in South Africa, speaks of the matter composing the long tail as being "striated."

SCIENCE NOTES.

According to the Gummi Zeitung, Dr. Karl Harries, professor of chemistry at the Kiel University, in an address delivered before the Engineers' and Architects' Society of Vienna, stated that samples of artificial rubber had been submitted to him by a leading German chemical works, and that shortly afterward he had succeeded in producing artificial rubber. After interminable fruitless attempts, he succeeded in transforming isopren, a constituent of rubber, which had previously been synthetically produced, into rubber. Prof. Harries exhibited samples of the artificial rubber which was in every respect entirely similar to the natural rubber.

In the process of separating the rare earths it is necessary to determine, from time to time, the degree to which the separation has been carried. If exact quantitative results are desired, it is advantageous to make use of some property which the various earths possess in widely different degrees. This is the case with the magnetic permeability. The magnetic balance of Curie and Chéneveau serves admirably for making these measurements, on either solutions or dry salts. By the application of this method to the intermediate fractional parts obtained in the separation of two nearly related earths it is possible to detect the presence of other elements which cannot be detected with the spectroscope.

Albert Brun, in the Revue des Sciences, cites experiments and observations made by himself and others to prove that, contrary to the prevailing opinion, water does not play the most important part in volcanic phenomena, and that eruptions and other manifestations of volcanic activity are not produced by the sudden generation of great volumes of water vapor. The fusing points of the lavas of different volcanoes range from 1,600 to 2,250 deg. F. When lava is melted it evolves gas so rapidly that it expands to at least twenty times the volume which it occupied in the solid state. This experiment can be repeated several times before all of the gas, which escapes with difficulty from the viscous liquid, is expelled. The gas is composed chiefly of chlorine, hydrochloric acid, sulphur dioxide, carbon dioxide and carbon monoxide. One-eighth of the volume consists of other gases. Ammonium chloride, formed during the eruption, is always present in small quantities (8 to 17 parts, by weight, in one million parts of lava). From the values of the co-volumes of these gases, it is calculated that their pressure at the moment of disengagement may amount to 175 tons per square inch. This enormous pressure is equal to the weight of a column of basalt more than sixty miles in height and is amply sufficient to move mountains. All of these gases are dry unless they have become mixed with air. The disengagement of chlorine alone is sufficient to account for the eruption. The gases are produced by the action of four classes of compounds upon each other and upon the lava. These compounds are hydrocarbons, nitride of silicon, chlorated silicates, and silicates of iron. Brun explains the frequent occurrence of geysers, suffioni, aqueous fumarolles and other evidences of the presence of water in volcanic eruptions as a subsidiary effect, due to surface and underground water. After the water of the upper strata has thus been eliminated, i. e., the moment of eruption, the true volcanic phenomenon appears in purity, and the lava ejected is absolutely dry. The temperature required for complete dehydration varies with the lava, i. e., with the volcano.

ELECTRICAL NOTES.

Some interesting observations on the effects of electricity on plant growth are published in the Journal of the Bath and West and Southern Counties Society. It is held that such fruits as strawberries are most suitable for treatment, since there seems to be some fear of "over-stimulation" in the case of fruit trees, and wheat is said to be less responsive, while legumes are adversely affected. Actual increases of production recorded are 39 per cent. in wheat, 65 per cent. in roots, and 80 per cent. in strawberries. It is suggested that the action of electricity is equivalent to that of an extra supply of sunshine; but that is surely somewhat of a makeshift theory. It might as well be said that sunshine is merely another method of applying the electrical treatment.

The February issue of the Journal of the Institution of Electrical Engineers contains a communication made to the Manchester section of the Institution by Mr. J. W. Warr, on the electric ignition of internal combustion engines. Descriptions of the principal methods of electric ignition at present in use are given, but the author expresses a decided preference for the high-tension method, both for stationary engines and for motor cars. The simplicity of the means of production of the current for low-tension methods is more than compensated by the trouble introduced by the mechanical contact breakers which are then necessary to produce the spark. Of the various high-tension methods, Mr. Warr considers that depending directly on a magneto machine to be the most trustworthy.

The researches which have been undertaken in the physical laboratory of the Johns Hopkins University, with a view to investigating the conditions under which the "corona" or brush discharge takes place from high-voltage transmission conductors above a certain value of voltage, have resulted in the general conclusion that the air is ionized at different values of electric intensity for different sizes of wire. It would also appear, states a contemporary, that while the point of breakdown or ionization does not occur at a definite value of electric intensity, observations on four sizes of conductor indicate that, if there is any effect of moisture in the air, the values of the voltage at which corona is formed are not influenced by more than 2 per cent. This applies to a range of moisture content from air which is quite dry up to the saturated condition. The influence of temperature is being studied, and the preliminary results indicate that for a range of from zero to 40 deg. C., there is a lowering of about 3 per cent in the value of the critical voltage.

There has recently been placed in service at Gothenburg, Sweden, an electric welding equipment fitted on an old barge that can be towed alongside any steamer needing repairs. The outfit includes a small marine boiler, with a De Laval turbine, working two direct-current generators. Duplicate cables can reach on board the steamer and to the inside of the boilers, if necessary, and make it practicable to do repairs in two places at once. One end of the barge has a workshop, with anvil and vise benches and a full equipment for small repairs. The anvil block is a steel slab 10.5 inches wide by 2.5 inches deep, supported on two wooden trestles, and the negative from the generator is clamped to it, the positive being the holder, with insulated handle, held in the operator's left hand. The current passes through the jaws holding the specially prepared rod, 3-16 inch in diameter, used for welding. The pieces to be welded, with chamfered edges, are secured in position on the anvil block, the rod is put to the point to be welded and slightly withdrawn. The electric arc thus formed quickly melts the end of the rod, causing a drop from it to adhere to the work. This is hammered, and the process repeated. A great variety of work can be done, and in butt welding a rate for ⅝ inch plates is about 10 feet an hour.

ENGINEERING NOTES.

The destructive effect of a locomotive blast at short range has been observed at the Cottage Farm bridge in Boston, which was built in 1896 with a clearance of only 15 feet over the tracks of the Boston and Albany Railroad. The floor was supported on hollow-tile arches strung between the webs and flanges of steel I-beams, the latter being protected by thick lead plate completely inclosing them and receiving the special skew-back tiles on their upper surface. Within ten years the blast ate entirely through the lower faces of the tiles and cut out pieces of the lead protection, so that in many cases they fell to the ground, necessitating the complete removal of both lead and tile. Another Boston bridge, over the Boston and Maine Railway lines, has wooden stringers, over the up-grade track, where the locomotives pass under forced blast; these stringers have been corroded to a depth of about ¼ inch, while over the down-grade tracks, where the locomotives do not run under forced draft, no erosion is noticeable. In bridges having a clearance of 18 feet above the tracks much less injury from locomotive blast is noted than where only the minimum of 15 feet is provided.

Mr. G. Gibbs, chief electrical engineer to the Long Island Railway and the Pennsylvania Tunnel and Terminal Railway, has presented a valuable report to the International Railway Congress on the operating costs of the Long Island and West Jersey electric railways. The Long Island road is virtually a crowded suburban line, while the West Jersey and Seashore road has runs of twenty-five miles without a stop and approximates to an express long-distance service. Both lines work with continuous current, but alternating current is generated at the power-house similar, it may be remarked, to the system on the Liverpool-Southport Railway. Electrification reduced the working costs per car mile by 36 per cent on the Long Island road, and by 8 per cent on the West Jersey. These figures indicate that main line electrification is a long way off, and if it does come will probably be due to the existence of a number of electrified zones in the neighborhood of the larger towns, which would naturally materially alter the problem of electrification for intervening stretches of route. With respect to the particular figures given above, it is important to remember that the saving referred to ignores the extra capital charges due to electrification.

According to a contemporary the crucible steel locomotive crank axles of the Swiss Federal Railways have hitherto been grooved in the crank pins, to fit projections on the bushes and retain the oil, it having been found that, without this precaution, nickel steel axles especially tend to become hot when running. While the grooves answer the purpose for which they were designed, they have, on the other hand, proved a source of probable danger, a number of these grooved axles having developed surface cracks, all of which start from the oil grooves. Some of these cracks extended for a length of nearly 12 inches, and measured up to 1¼ inches deep, with an outward curve toward the crank. In considering the choice of material for replacing these cracked axles, comparative impact tests have been made, under the auspices of the Swiss Association for Testing Materials, with nickel steel and crucible steel, greatly to the disadvantage of the latter material, which is also far more sensitive to rapid sectional changes, to which the formation of surface cracks is probably attributable. From the results of these tests the new specification for locomotive crank axle prescribes steel with 5 per cent of nickel, the oil grooves being abolished and the transition curve between the crank pin and arm increased from 12 millimeters to 20 millimeters radius.

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